

**NUTRIENT CONTENT OF DIFFERENT TYPES
OF LUNCHTIME MEAL, AND THEIR
CONTRIBUTION TOWARDS THE OVERALL
DAILY NUTRIENT INTAKES OF 11-14-YEAR-
OLD SCHOOLCHILDREN FROM TWO
SCHOOLS IN SCOTLAND**

A thesis submitted for the degree of
Doctor of Philosophy

QUEEN MARGARET UNIVERSITY

2010

Abstract

Introduction

Due to concern regarding the quality and health implications of schoolchildren's diets, large amounts of funding have been invested into improving school canteen lunches. However, children may also have packed lunches, or 'street' lunches (those purchased outside school). This study was undertaken to ascertain whether canteen lunches are nutritionally superior to packed and street lunches, the contribution of the lunch types towards total nutritional intake, and whether children who eat nutritionally poor lunches compensate with food consumed at other times.

Method

During 2007 and 2008, dietary intake data was collected from 332 children aged 11 - 14, from two secondary schools in Fife, Scotland.

Using 5-day estimated intake food diaries, data from 1,532 days was collected. Nutrient intake and density for 9 nutrients (plus fruit/vegetables) included in the Scottish Nutrient Standards for School Meals (2003) were compared with the Scottish Nutrient Standards for School Lunches (for lunchtimes) and Dietary Reference Values (for the whole day). Comparisons were undertaken between canteen, packed and street lunches, and between days including them.

Results

Many children 'flitted' between canteen, packed and street lunches on different days. Some children also consumed food from more than one lunch type on a single day.

Dietary quality was poor; intakes of non starch polysaccharide, iron, and fruit and vegetables (at lunchtime and over the whole day) were of particular concern.

When canteen lunches were consumed, the diet was closest to guidelines. However, many dietary targets remained unmet. When street lunches were consumed, the diet was furthest from the guidelines. This was the case both at lunchtime and over the whole day.

There was some compensation for poor lunchtime nutrient intake by foods eaten at other times during the day. However, this was not as great as noted by previous studies, and many significant differences between the lunch types existed at the end of the day.

Conclusion

Due to the superior nutritional quality of canteen lunches compared with the other options available, and the contribution of canteen lunches towards overall nutrient intake, children should be encouraged to have canteen lunches.

Keywords: school meal, school meals, school lunch, school lunches, children's nutrition, nutrient intake, packed lunch, packed lunches

Acknowledgements

I would like to express my sincere gratitude to the following people who have provided help and support during the work for this thesis.

My supervisor, Michael Clapham

My second supervisor, Professor Isobel Davidson

Dr Robert Rush, Queen Margaret University, for his advice on statistical methods.

Queen Margaret University for the bursary for my studies.

Queen Anne High School, Dunfermline, and St Columba RC High School, Dunfermline (and especially the home economics and catering staff) for their co-operation and help.

The children at the above schools, for their enthusiastic participation.

My family, especially my mother Heather, and my husband Graham, for their patience, encouragement and support.

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Abbreviations

BMI	Body mass index
BMR	Basal metabolic rate
DRV	Dietary reference value
EAR	Estimated average requirement (for energy)
EI	Estimated intake
FFQ	Food frequency questionnaire
FSA	Food Standards Agency
FSAS	Food Standards Agency Scotland
LRNI	Lower reference nutrient intake
NDNS	National Diet and Nutrition Survey
NMES	Non-milk extrinsic sugars
NSP	Non-starch polysaccharides
PAL	Physical Activity Level
RNI	Reference nutrient intake
SFA	Saturated fatty acids
SNSSL	Scottish Nutrient Standards for School Lunches, the nutrient standards in place at the time of the present study. These were later updated (Scottish Government 2008b).

Chapter 1 – Introduction

Literature review

1.1) An introduction to the poor nutrition provided by children's diets

Nutrition is an important influence throughout an individual's lifespan, playing a crucial role in development, growth, maintenance of health and the prevention of disease. A poor diet is a risk factor for conditions including obesity, diabetes, cardiovascular diseases, cancer, osteoporosis and dental disease (World Health Organization 2003). Indeed, a large proportion of the preventable disease burden in the developed world is considered to be due to poor diet. For example, just under 30% of coronary heart disease and almost 20% of stroke is estimated to be due to low fruit and vegetable consumption (World Health Organization 2002).

Children's diets have been recognized as being poor in terms of high intakes of nutrients considered harmful in excess, and low in micronutrients (Buttriss 2002), and the National Diet and Nutrition Survey (NDNS) of young people conducted in 1997 (Gregory & Lowe 2000) found that young people eat more than the recommended levels of non-milk extrinsic sugars (NMES), sodium, and saturated fatty acids (SFA), and not enough fibre (non-starch polysaccharide, or NSP), fruit and vegetables. The NDNS surveyed children aged 4 – 18 years; in the older children (11 – 18 years), intakes of vitamin A, zinc and calcium fell below the Lower Recommended Nutrient Intake (LRNI). Girls in this age range also had iron intakes below the LRNI.

In 2010, the first results (with data collected during 2008-9) from the most recent National Diet and Nutrition Survey were published (Bates, Lennox, & Swan 2010). Dietary intakes for children were broadly similar to previous surveys, with very small decreases in percentage of food energy from NMES, fat and SFA, and slight increases in intakes of vitamin A, vitamin C and calcium. However, because this is the first year of a new 'rolling' programme, the sample size for this first release of results was small (224 children aged 11 – 18) and the authors noted the limitations this placed on

statistical analysis and advised that comparisons with previous surveys were observed differences, not statistically significant differences.

In many respects children's diets deteriorate with age, with teenagers' diets appearing to be less healthy than those of younger children. For example, there is a tendency towards increased intake of sweets and sugar-sweetened beverages (Vereecken, Ojala, & Jordan 2004), and a decrease in the variety of foods in their diet, their likelihood of eating breakfast, and consumption of fruit, vegetables and milk (Lytle et al. 2000).

This review will firstly examine the characteristics of children's diets in general, before reviewing studies on children's nutrition in the UK. It will then discuss the health implications of childhood diet. The present study is concerned with Scottish children's diets in particular, and this introduction will examine the particular characteristics of the Scottish diet, and review the literature on Scottish children's diets. Scotland's distinct nutrition policy will also be described. School meals (and their comparison with other lunchtime options) form the basis of the present study, and this review will evaluate the literature on children's lunch options (canteen and packed lunches, as well as food purchased outside school), including studies comparing the different lunch options.

1.1.1) A review of the characteristics of children's food choices, including their intakes of 'fast food' and sugar-sweetened drinks

Although 70% of children have been found to self-report that their diet is 'healthy' or 'very healthy' (Sodexo 2005), other research suggests this is far from the case. The 1997 Diet and Nutrition Survey of young people (Gregory & Lowe 2000) found that children were eating more than the recommended amounts of sugar, salt, and saturated fat, and not enough fruit and vegetables. The foods most commonly consumed by young people in the survey, eaten by more than 80% of the group during the 7-day recording period, were white bread, savoury snacks, potato chips, biscuits, boiled, mashed and jacket potatoes and chocolate confectionery. The survey also found boys

eating (by weight), nearly four times more biscuits than leafy green vegetables, and girls eating more than four times as much sweets and chocolate as leafy green vegetables.

Compared with earlier surveys (Gardner Merchant 1991; Gardner Merchant 1998; Gregory & Lowe 2000), children's diets appear to be deteriorating, with increasing popularity of fizzy drinks and increasing prevalence of unhealthy eating patterns such as missing breakfast or helping themselves to supper from the fridge (Gardner Merchant 2007). The initial data from the most recent NDNS for children and young people (Bates, Lennox, & Swan 2010) showed some positive progress towards reducing fat, SFA and NMES intake, but due to the small sample size this data cannot be said to indicate any new trends.

As children grow older, particularly upon reaching adolescence, they gain more control over their food choices and eat more of their food outside the home (Truswell & Darnton-Hill 1981; Koletzko et al. 2004). This tends to lead to diets becoming less conducive to good health, for example with less breakfast-eating, a reduction in dietary variety, and decreasing fruit, vegetable and milk intake (Lytle et al. 2000). When children are given the opportunity to select their own food, they tend to choose foods high in fat, SFA and sugar, (Ludwigsen & Sharma 2004), the effect of which is shown in higher than recommended intakes of SFA and sugar (Gregory & Lowe 2000).

Children, especially when they reach the teenage years, typically consume more fast food and confectionary than other age groups (Anderson, MacIntyre, & West 1994), and Ludwigsen and Sharma's report "Burger Boy and Sporty Girl" (2004) on children's attitudes towards food, which interviewed 174 schoolchildren in England, Wales and Scotland, found that children described 'fast food' as the most tasty and desirable. Young people who eat fast food have been found to have higher intakes of energy, total and saturated fat, and sugar, than those who do not (Bowman et al. 2004). Their diets are also more energy-dense (and by implication proportionately poorer in nutrients). Fast food eaters also eat less of foods associated with decreased risk of chronic disease: milk, fruit and non-starchy vegetables (Bowman et al. 2004).

The popular media often portrays a link between fast food and obesity, but a review of the literature suggests that the situation is not clear cut. A study of adults (aged 20 – 45 years) found that the number of fast food meals per week was positively correlated with body mass index (BMI) in women, but not men (Jeffery & French 1998). In contrast, a study of adolescents found a greater energy intake from high-calorie low-nutrient-density foods (sweets, chips, soft drinks, baked goods and ice cream) in non-obese than obese adolescents, and little difference in percentage energy from these foods between the two groups (Bandini et al. 1999), suggesting that if obese adolescents are consuming too many calories, they are coming from sources other than fast food.

In addition, while the popular media has often linked the increase in diet-related health problems, and particularly obesity, with increasing fast food consumption, the intake of some popular fast foods could be declining among young people. The frequency of chip eating among young people has decreased since the 1990's to a frequency of two to three times per week (Sodexo 2005; Gardner Merchant 2007).

Regarding sugar-sweetened drinks, these beverages are increasingly popular among children (Summerbell et al. 1995; Gardner Merchant 1998), being consumed in large amounts (Gregory & Lowe 2000), with consumption increasing through the teenage years (Alexander et al. 2004). A study of 11 – 14-year-old children in Liverpool (Johnson & Hackett 1997) reported that 67% of the subjects consumed sugar-sweetened drinks on the study day, and in a food intake questionnaire of 11 – 12-year-old children, also in Liverpool, 58% of the subjects listed sugar-sweetened drinks (Hackett et al. 2002).

Several studies have found sugar-sweetened drinks to be associated with obesity in children (Ludwig, Peterson, & Gortmaker 2001; Nicklas et al. 2003; Mrdjenovic & Levitsky 2003). An analysis of the NDNS data for children (Gibson & Neate 2007) found a weak association between high soft drink intake and BMI, and in its review of 23 studies on this subject, the same paper found 11 positive associations, 3 non-significant positive associations, and 9 studies finding no association. In women, sugar-sweetened beverages have been associated with a greater magnitude of weight gain and

increased risk of type 2 diabetes (Schulze et al. 2004), and in another study of adult men and women, an association was found between soft drinks consumption (diet and regular varieties) and increased incidence of metabolic syndrome (Dhingra et al. 2007). However, other research found an inverse relationship has been found between NMES intake, and Body Mass Index and fat intake (Gibson 1996).

The other main health problems raised regarding children's consumption of these drinks are dental problems (NHS Scotland 2002; Marshall et al. 2003), obesity (Nicklas et al. 2003), and nutrient dilution (Johnson & Frary 2001), especially by displacing milk (which is higher in protein, calcium and vitamin A) from the diet (Harnack, Stang, & Story 1999; Mrdjenovic & Levitsky 2003).

1.1.2) *The characteristics of children's intakes of energy, fat, saturated fatty acids, non-milk extrinsic sugars, non-starch polysaccharides, vitamin A, folate, calcium, iron, and fruit and vegetables*

Energy, fat, SFA, NMES, NSP, vitamin A, folate, calcium, iron, and fruit and vegetables, have been selected for special consideration in this literature review, as particularly important nutrients (and foods) included in the Scottish Nutrient Standards for School Meals (SNSSL) (Scottish Executive 2003b), and the focus of the present study. Previous nutritional studies of children have tended to find energy intakes lower than the Estimated Average Requirements (EARs). For example, the NDNS of young people (Gregory & Lowe 2000) found an energy intake of 1,672kcal for girls and 1,968kcal for boys aged 11 - 14, compared with the EAR of 1,845kcal for girls and 2,200kcal for boys. The Department of Health survey of school children's diets (Department of Health 1989) also found children's mean energy intake to be approximately 10% below the EAR. However, it is likely that some of this difference could be accounted for by under-reporting.

The Department of Health survey (Department of Health 1989) found the proportion of children's energy intake provided by fat to be 37.7% for children aged 10 – 11, and

38.3% for children aged 14 - 15, above the recommendation of no more than 35% (Department of Health 2003b). However, the figures from the National Diet and Nutrition Survey (NDNS) for young people (Gregory & Lowe 2000) were in line with the recommendation. The NDNS found children to be eating too much saturated fatty acids (SFA) (14.2% of dietary energy, therefore above the COMA recommendation of 10%).

The findings of the Low Income NDNS (LINDNS) conducted in 2004 (Nelson et al. 2007a) were extremely similar to that of the NDNS in this respect, with fat contributing 36.6% of total energy, and saturated fatty acids (SFA) providing 14.5%, suggesting that the diets of families under economic pressure are not necessarily higher in fat. In both the NDNS and LINDNS, children's intakes of monounsaturated fats were lower than Department of Health recommendations (Department of Health 2003b).

Mainly because of their implications for dental health (NHS Scotland 2002), the COMA panel on Dietary Sugars (Committee on Medical Aspects of Food Policy 1989) proposed that intakes of sugar should not exceed 10% of total energy. The NDNS of young people (Gregory & Lowe 2000) showed children's intake of non-milk extrinsic sugars (NMES) higher than the COMA recommendation, providing 16.7% of energy in boys and 16.4% in girls. The figure found by the LINDNS carried out in 2004 (Nelson et al. 2007a) found an intake of 17.1% in boys and 16.5% in girls, suggesting that this intake pattern cuts across socio-economic divides.

There is some evidence that high sugar intakes, and high intakes of sugar-sweetened drinks in particular, are associated with poor dietary quality (Johnson & Frary 2001). Some research suggests that so-called 'empty calories' (energy consumed accompanied by little contribution of beneficial nutrients) provided by sugar may become a problem if children's food and energy intake continues to fall, as adequate nutrient intakes may become difficult to achieve (Rugg-Gunn et al. 1991).

Other studies, however, find a lack of data on evidence of detrimental health consequences (aside from that on dental health) caused by dietary sugars at intakes consumed by the children, and some researchers, including Wolever and Miller (1995)

have pointed out that sugar might not merely be considered a source of empty calories, and suggest that undue avoidance of sugar is unnecessary and might be counterproductive if it results in increased intakes of fat and high glycaemic index starch.

The Dietary Reference Value (DRV) for non-starch polysaccharide (NSP) for adults in the UK is 18g, but there is no recommendation for children, aside from that they should have 'proportionately lower' NSP intakes (Department of Health 1991). Most studies involving teenagers use the adult DRV, and this was the course taken in the present study. Probably due to their dislike of wholegrain cereal products, fruit and especially vegetables, evidenced by their food choices in the NDNS (Gregory & Lowe 2000), children do not consume enough fibre, a finding borne out by a report discussing studies on children's diets conducted in the 1980s and 1990s (National Forum for Coronary Heart Disease Prevention 1993), and the NDNS of young people (Gregory & Lowe 2000), which found the NSP intake of children aged 11 – 14 to be 10.9g, which is lower than the DRV of 18g (Department of Health 2003b).

Regarding vitamin A, children's main sources are vegetables (especially carrots) and dairy products (Department of Health 1989; Gregory & Lowe 2000), and children with vitamin A intakes below the Reference Nutrient Intakes (RNI) are found in all age groups, with intakes below the Lower Reference Nutrient Intake (LRNI) found in up to 20% of older girls and 13% of older boys (Gregory & Lowe 2000).

At age 11 – 14 the NDNS found folate intakes of 247ug for boys, and 210ug for girls, amounting to 123% and 102% of the RNI for boys and girls. However, 33% of boys and 50% of girls had intakes below the RNI of 200ug. The main dietary sources of folate for children were cereals and cereal products, and vegetables, potato products and savoury snacks (Gregory & Lowe 2000).

Teenagers' calcium consumption may fall below the recommended daily intake (National Forum for Coronary Heart Disease Prevention 1993), particularly in girls, with 57% of 15-year-olds consuming below 700mg (the RNI being 800mg for girls and 1,000mg for boys at this age) (Department of Health 1989). The mean calcium intake found by the NDNS was 799mg for boys, and 641mg for girls, aged 11 – 14 (Gregory & Lowe 2000). These low calcium intakes are probably due to a decline in consumption of milk and other dairy products with age (Currie & Todd 1992; Gregory & Lowe 2000).

Iron requirements are particularly high during adolescence. Menstrual losses increase female requirements to an RNI of 14.8mg at age 11, and boys' requirements during puberty also increase to an RNI of 11.3mg at age 11, due to their increasing lean body mass and haemoglobin (Department of Health 1991). Mean intakes of children, except older boys, have been found to be below the recommended amount (Department of Health 1989). The NDNS found 45% of 11 – 14-year-old girls to have intakes below the Lower Reference Nutrient Intake (LRNI) (Gregory & Lowe 2000).

Children's fruit and vegetable intake is low (lower in boys than girls), and decreases with age (Gregory & Lowe 2000; Alexander et al. 2004). The 2001/2 HBSC Survey of 11 – 15-year-old children's health behaviours in 35 countries found that on average, only 30% of boys and 37% of girls reporting eating fruit at least once a day (Vereecken, Ojala, & Jordan 2004), a figure that decreased with age. Less than 50% of children in the survey ate vegetables daily. The findings of the 2001/2 survey were supported by those of the 2005/6 HBSC Survey (Currie et al. 2008).

1.1.3) A review of studies conducted in England, Northern Ireland and the UK, on children's energy and nutrient intakes

Despite the prominent coverage of children's diets in the popular media, the amount of recent scientific research in this area is relatively small (especially for older children), and few large scale dietary surveys have been conducted.

In 1983, a dietary survey of 2,697 British Schoolchildren (with an enhanced sample of 884 primary schoolchildren) took place, commissioned by the then Department of Health and Social Security (Department of Health 1989). This study utilised 7-day weighed dietary records.

The NDNS for young people aged 4 – 18 (Gregory & Lowe 2000) was carried out in 1997 and included a sample of 1,701 children, using 7-days' weighed dietary intake records, along with physical measurements, blood pressure, and bowel movements. A sample of blood and urine was also requested, and children aged over seven also kept a 7-day physical activity diary.

Several other studies have been published in recent years on children's nutrient intakes – only those considering the age group of the present study are considered in this literature review. Studies of Scottish children are considered later.

To enable comparison of study data with nutritional reference values, Table 1 shows the Estimated Average Requirement for Energy, the Dietary Reference Values and Reference Nutrient Intakes for children aged 11 – 14 (Department of Health 2003b).

Table 1: Estimated Average Requirement for Energy, Dietary Reference Values and Reference Nutrient Intakes for children aged 11 – 14

	Energy (Kcal)	Fat (g)	SFA (g)	NMES (g)	Vit A (ug)	Fol (ug)	Ca (mg)	Fe (mg)
Male	2,200	85.5	24.4	55.0	600	200	1,000	11.3
Female	1,845	72.0	20.5	46.0	600	200	800	14.8

Source: (Department of Health 2003b) (Figures for fat, SFA and NMES are based on the population DRVs, which is expressed as percentage energy from these nutrients)

Table 2 (following page) shows selected results of UK studies of dietary intake of young people. The data in the table is confined to subjects of a comparable age to that considered by the present study (the studies in the table may also have involved younger and/or older children).

Table 2: Selected results of studies conducted in England, Northern Ireland and the UK, of dietary intake of young people

Author	N	Study year	Age	Sex	Method	E (kcal)	Fat (g)	SFA (g)	NMES (g)	Total sugars (g)	NSP	Vit A (ug)	Fol (ug)	Ca (mg)	Fe (mg)
Cook, J. et al, 1973	124	1968-70	13-14	M	7DWI	2,771						1,170		1,038	14
	110			F		2,067						1,036		759	12
Darke, S. et al, 1980	47	1970	14	M	7DWI	2,569	109.4		101.6			749		887	12.5
	41			F		2,081	92.0		69.7			717		731	11.0
Hackett, A.F. et al, 1984	405	1979	11-12	M	3DEI	2,125	92.6			121.0					
				F		1,935	86.6			114.0					
	405	1980	12-13	M	3DEI	2,221	99.5			121.8					
				F		1,982	90.8			109.2					
Adamson, A. et al, 1992	379	1980	11-12	M	3DEI	2,126	94.9			119.4		527		850	10.1
				F		1,975	90.0			115.0		471		751	9.2
	379	1990	11-12	M	3DEI	2,054	90.8			117.4	9.4	552		786	11.7
				F		1,970	88.9			118.5	9.0	585		763	11.2

Author	N	Study year	Age	Sex	Method	E (kcal)	Fat (g)	SFA (g)	NIMES (g)	Total sugars (g)	NSP	Vit A (ug)	Fol (ug)	Ca (mg)	Fe (mg)
Dept of Health, 1989	902	1983	10-11	M	7DWI	2,070	87.6		87.6			845		833	10
	821			F		1840	78.9		78.9			641		702	8.6
	513		14-15	M		2,484	106.3		106.3			969		925	12.2
	461			F		1,875	82.2		82.2			801		692	9.3
Strain, J.J., et al, 1994	251	1990	12	M	DH	2,627	112	45.6		139				1,030	
	258			F		2,197	94	36.3		121				830	
Gregory, J. & Lowe, 2000	179	1997	11-14	M	7DWI	1,979	77.2	30.3	90.0		11.6	577	247	799	10.8
	238			F		1,660	67.2	26.2	73.0		10.2	558	210	641	8.8

N = number of children in the study, of the age in the table (study may have considered older and/or younger children also)

Abbreviations:

7DWI = 7 day weighed intake

3DEI = 3 day estimated intake

DH = Diet history

With reference to Table 2, all of the studies selected for review involve large sample sizes (the smallest being the study by Darke et al (1980) involving 88 children), and used a variety of methodologies. Overall conclusions are difficult to draw, but it appears that children of this age group have intakes of SFA and NMES, that are too high, and do not consume sufficient calcium and iron (intakes below the RNI), with the iron intakes of girls being of particular concern.

The study by Cook et al (1973) was designed to examine the relationship between socioeconomic factors and nutrient intake. The survey utilised 7-day weighed intake methodology, and involved a total of 1,017 children aged 8 – 14 (the data in the table is confined to those aged 13 - 14). The mean energy intake was above the EAR (providing 126% of the EAR for boys, and 113% for girls). Intakes of several micronutrients were measured, but this review is confined to those concerning the present study, namely vitamin A, calcium and iron. Cook et al found the mean vitamin A intake to be well above the RNI, but calcium and iron intakes of girls in the sample were very slightly below the RNI.

Darke et al (1980) focused on the differences between children from one-parent families and those living with both parents (the control group). Seven-day weighed intake data was collected; weighing and the long recording period enhanced validity, though possibly reduced compliance. The data in Table 2 is that from the control group only, and the researchers stated that there was no evidence of undernutrition, though mean calcium and iron intakes were below the RNIs, most notably providing only 74% of the RNI in the case of girls' iron intakes. In addition, mean energy intakes were above the EAR, mean fat intakes were above the DRV, and some children were obese.

The study by Hackett et al (1984) was a two-year longitudinal survey of 405 English children initially aged 11.5 years. Three-day estimated intake data was collected for a variety of nutrients; only those relevant to the present study are recorded in the table, namely intakes of energy, fat and sugars, all of which increased with the children's age. In common with the previous study, intakes of energy and fat were above recommendations. Sugars were measured rather than NMES, and a dietary reference value does not exist for

total sugars (Department of Health 2003b), so it is not possible to state whether this figure is too high. Some of the other studies in Table 2 also measured total sugars.

Adamson et al (1992) examined the diets of children in England, in 1980 compared with 1990, using 3-day estimated intake records. Energy intake fell between data collection for the two surveys in boys but not girls, and nutrient density improved (though intakes of vitamin A, calcium and iron were below RNIs in both surveys). In common with most studies in this review, fat intakes were above recommendations in both surveys.

The Diets of British Schoolchildren report (Department of Health 1989) is the largest study in this review, involving 2,691 children of the age considered by the present study, and using extremely rigorous methodology. A longer recording period (seven days) was used, along with weighed intakes, enhancing precision and validity but possibly reducing compliance. The sample was subdivided into children aged 10 – 11, and those aged 14 – 15; however, the DRVs for fat, SFA and NMESs are set for children aged 7 – 10 and 11 – 14. Therefore, each study category contained children older than those in a particular DRV band, making it impossible to state definitively whether the children surveyed met the recommendations or not. However, in the case of NMES, the 10 – 11-year old sample's intake provided 179% of the DRV for 7 – 10 year olds in the case of boys, and provided 161% of the DRV for 7 10-year-olds in the case of girls. The 14 – 15-year-old sample's intake provided 192% of the DRV for 11 – 14-year-olds in the case of boys, and 178% of the DRV in the case of girls. It would seem unlikely that larger amounts of food eaten by the 11-year-olds and 15-year-olds could account for this much of an excess in NMES intake.

When micronutrient intakes are considered, the RNIs for 11 – 14-year-olds are the same as those for 15 – 18-year-olds, so the 14-15-year-olds in the study can be compared with this reference value. In the case of vitamin A, the sample means exceeded the RNI; most of the other studies in Table 2 also exceeded the RNI, suggesting that vitamin A intake is not a serious concern in children and adolescents. For calcium, the 14 – 15-year-olds in the Diets of British Schoolchildren Report's calcium intakes were compared with the RNI; the sample provided only 83% of the RNI in the case of boys and 88% in the case of girls.

For iron, the 14-15-year-old boys in the study exceeded the RNI, but the mean intakes of the 14 – 15-year-old girls in the study were only 68% the RNI.

The study by Strain et al (1994), involved children aged 12 and 15, though only data from the 12-year-olds (the age surveyed in the present study) is shown in the table. Although iron and calcium intakes met requirements, once again, calorie intakes exceeded the EAR, and fat intakes were even more excessive (providing 130% of the DRV in the case of 12-year-olds). Total sugar intakes were of most concern, at more than double the DRV for NMES for this age group, and the authors concluded that some concern about the dietary habits of children of this age in Northern Ireland appeared justified.

The data from the Gregory and Lowe (2000) study in Table 2 comprises the results from children aged 11 – 14, from the National Diet and Nutrition Survey. Although in its entirety the study surveyed a much larger sample, only 417 were aged 11 – 14, a similar sample size to most of the other studies in Table 2. In common with the Department of Health report (1989), this study used 7-day weighed intake records, and notably found lower intakes of energy, fat and SFA compared with the other surveys reviewed; some of this might be due to an effect of the methodology, with the other studies' shorter recording periods contributing to the recording of higher intakes of energy and macronutrients, or the longer, 7-day methodology contributing to under-reporting. The NDNS data for energy and fat intakes met the EAR and DRV for this age group, but the SFA intake exceeded the DRV. NMES intakes were also notably lower (as in the Department of Health study) than the other studies reviewed, but still significantly above the DRV. As well as noting the high fat SFA and NMES intakes, the authors commented that intakes several micronutrients were sufficiently low to be of concern. Micronutrient intakes were the lowest of the studies reviewed, and failed to meet the RNIs for the micronutrients considered in this review, with the exception of that for folate. Calcium intakes fell short of the RNI for 11 – 14 years olds of both genders, and while the iron intake for boys provided 96% of the RNI, that for girls provided only 59% of the RNI. It is not certain whether these particularly low micronutrient intakes are at least partially due to under-reporting, but because of the high-quality nature of this study, plus the fact that SFA and NMES intakes exceeded recommendations, it is

likely that at least part of this lack of micronutrients was due to the poor nutrient value of the children's diets.

1.1.4) A review of studies on UK children's intakes of foods and food groups

Other studies considered eating behaviour, as well as or rather than nutrient intakes. A food record study of 375 English children aged 11 – 14 (Hackett et al. 1986) found potatoes (including chips and crisps) to be the largest single source of energy, while 'meat' provided the main source of protein and fat (with spreading fats, chips, crisps and milk also providing important fat sources). Chips were the main fibre source, though white bread, crisps and baked beans contributed similar proportions.

A dietary recall study of 707 Liverpool schoolchildren aged 11 - 14 (Johnson & Hackett 1997) noted that many children chose less nutritionally desirable foods, such as crisps, chips, sugar-sweetened drinks, chocolates and sweets, leading to poor dietary quality overall. Although fruit was consumed the previous day by 68% of the children, the other foods commonly eaten were less nutritionally desirable, with 68% eating crisps, 67% drinking sugar-sweetened drinks, 64% eating chips and 62% eating sweets/chocolate.

A food intake questionnaire of 3,556 children aged 9 – 10 and 649 aged 11 – 12, living in Liverpool (Hackett et al. 2002), produced similar findings. Fruit was listed by 69% of the 11 - 12-year-olds, but the other foods frequently mentioned were less healthy, including sugar-sweetened fizzy drinks (58%), cordial (57%), sweets (56%) and chocolate (48%). Only 21% of secondary school age children ate both fruit and vegetables the previous day, and 26% ate neither fruit nor vegetables. Overall, girls' diets were closer to recommendations than boys', and breakfast eating declined with as children grew older, and especially into the teenage years (particularly in girls).

1.2) The impact of childhood diet on children's current and future health

Diet in childhood has an immediate impact on health, contributing to susceptibility to illness, anaemia, obesity and dental disease (British Medical Association Board of Science and Education 2003; Vereecken, Ojala, & Jordan 2004). Evidence also exists that adult susceptibility to disease is associated with nutrition in childhood and adolescence (Caballero 2001), and the early manifestations of chronic disease are being seen earlier in younger children than previously (World Health Organization 2003).

1.2.1) The impact of childhood diet on children's current dental health and behaviour

The effect of children's high intake and frequency of consumption of sugar on dental health makes itself known before adulthood (Kandelman 1997). Although factors including genetics, dental hygiene and fluoride are relevant (Walker 1995), sugar-rich diets appear to predispose to dental decay. NMES intake has been found to be significantly higher (mean 18.5% food energy) in children who had received treatment for decay than in children who had not (mean 16.1% food energy) (Kandelman 1997).

While it is undeniable that malnutrition of the kind seen in the developing world can impair intellectual performance, the short-term influence of children's diets on cognitive and academic performance appears much less marked in better-nourished children in the developed world (Sorhaindo & Feinstein 2006). Although many children's diets are nutritionally poor, with associated implications for their long-term health, this does not appear sufficient to impair their intellectual performance (Nelson 1991) and providing nutritional supplements to healthy 7 – 12-year-old children did not significantly alter their performance in IQ tests (Nelson et al. 1990).

Reports in the popular press have linked children's high sugar intake with hyperactivity, but reviews of the scientific literature (White & Wolraich 1995; Wolraich, Wilson, & White 1995), including both normal children and those suffering from behavioural disorders such

as ADHD, concluded that although some children might react badly to sugar (in terms of ADHD symptoms and aggression) evidence for the proposed link between sugar and hyperactivity was inconclusive at best, and studies were just as likely to find that sugar improved behaviour. The authors suggested that parental expectation could account for many reports of a link between sugar and behaviour, as in studies when children were given a drink sweetened with artificial sweetener, but parents were told it contained sugar, behavioural effects were commonly reported. Where detrimental behavioural effects did exist, they were more likely to be seen in pre-school children.

However, it is still possible that children with poor diets and nutrient deficiencies might be held back academically. Blood sugar fluctuations can contribute to problems with concentration in class (Sorhaindo & Feinstein 2006), as can iron deficiency anaemia (Grantham-McGregor & Ani 2001), and missing breakfast (Simeon & Grantham-McGregor 1990). A less obvious effect of nutrition on academic attainment can be seen when reduced immunity leads to illness and therefore poor attendance (Sorhaindo & Feinstein 2006). Deficiency in nutrients such as vitamin A, carotenoids, zinc, iron or essential fatty acids, can compromise immunity, as can diets excessive in total fat, and obesity (Chandra 1993).

Also, if poor dietary choices contribute to excess weight gain, emotional consequences of overweight in terms of poor self esteem may make themselves apparent immediately (more so in girls than boys) in children who are only slightly overweight (Strauss 2000), and persist throughout life. (Strauss 2000). A seven-year follow-up study of obese adolescents found an association between obesity and negative social consequences later in life, stronger than that found for other chronic conditions, and even when adjusted for confounders such as socioeconomic origins and ability (Gortmaker et al. 1993).

1.2.2) *The influence of childhood food preferences on adult dietary choices*

There is evidence (Singer et al. 1995) that children's food preferences track into adulthood, increasing the importance of establishing healthy attitudes in childhood. It

appears that this phenomenon is most important in younger children: a study following children between the ages of three and eight found evidence of tracking, particularly for carbohydrate, fat and saturated fat. Supporting this, a seven-year study commencing at age 11 also found evidence of tracking, suggesting that food preferences are largely 'fixed' by age 11, and that healthy habits need to be established before this (Kelder et al. 1994). However, a dietary survey repeated when children were 12 and 15 years of age found that individual dietary patterns at 12 years were unlikely to be predictive of energy and nutrient intake at 15 years (Robson et al. 2000), implying that some flexibility still remains when the teenage years are reached, and suggesting that it may still be possible to positively shape teenagers' eating behaviour. This is supported by a study of individuals from the age of 13 to 33 years, showing only moderate stability, though this stability increased with age (Post et al. 2001).

1.2.3) *The effect of childhood and adolescent diet and the increasing prevalence of obesity during these stages on cardiovascular risk factors and future cardiovascular health*

Hypertension, raised cholesterol and atherosclerosis are often precursors of heart disease and stroke, and are now being seen in adolescents and even children (Berenson et al. 1998; Williams et al. 2002). These conditions, as well as the eating habits that predispose to them, track from childhood to adulthood (Kavey et al. 2003). Although total fat intake, and the proportion of saturated fat in the diet, is important, the main adolescent predisposing factors for adult cardiovascular disease appear to be overweight and obesity (Must et al. 1992), and weight gain during childhood and adolescence appears to be a greater risk factor than actual weight at any fixed point in time (Sinaiko et al. 1999). Indeed, obesity in young people is a major predictor of ill health in childhood and adulthood (Reilly et al. 2003), and is correlated with obesity in adulthood (Guo & Chumlea 1999; World Health Organization 2003), especially if there is obesity during adolescence (Whitaker et al. 1997).

Prevalence of childhood obesity in England is increasing (NHS Information Centre, 2010). The Scottish Health Survey of 2009 (Scottish Government 2010c) indicated that the prevalence of childhood obesity among boys in Scotland increased between 1998 and 2008, but showed a significant downturn in 2009. However the survey authors suggested this may be a short-term effect of sample fluctuation. Fewer Scottish girls than boys were obese at each point in time, and the change in prevalence between 1998 and 2009 was not statistically significant for girls (Scottish Government 2010c). However, the degree of obesity appears to be increasing over time (The Information Centre NHS 2008), as is the degree of obesity in individual children (Livingstone 2001). The prevalence of childhood overweight and obesity has been forecast to continue to rise both in England (Zaninotto et al. 2006), and also in Scotland (Scottish Government 2010c), the focus of the present study.

The rising prevalence of obesity in the last 20 years has been accompanied by an increase in type 2 diabetes (Hannon et al. 2005) and while this was previously viewed as an adult disease, it is now seen increasingly in adolescents and even children (American Diabetes Association 2000). The suite of symptoms associated with insulin resistance (and therefore type 2 diabetes) known as the metabolic syndrome, includes hyperinsulinaemia, hypertension, elevated plasma triglycerides and low-density lipoprotein, cholesterol levels and central obesity. The clustering of these predisposing factors – many of which are also risk factors for cardiovascular disease (Williams et al. 2002) – is increasingly seen in children and adolescents (Berenson et al. 1998), and tracks into adulthood, with individuals contracting type 2 diabetes in childhood or adolescence experiencing cardiovascular complications of their condition earlier than adults developing type 2 diabetes (Hannon et al. 2005). Energy intake in childhood is also associated with adult mortality from non-smoking related cancers (Frankel et al. 1998).

1.2.4) The particular effect of children's low fruit and vegetable consumption on future cancer and cardiovascular disease risk

The lack of fruit and vegetables in children's diets (Gregory & Lowe 2000; Hackett et al. 2002) is particular cause for concern, since these foods are rich in NSP and antioxidants

believed to be protective against diseases including cancer (Slattery et al. 2000) and cardiovascular disease (Brown et al. 1999; Yochum et al. 2000; Iannuzzi et al. 2002).

Increased fruit intake in childhood has been correlated with reduced incidence of cancer in adulthood (Maynard et al. 2003). Perhaps surprisingly no link was found for vegetables. Also, more recent data from the EPIC cancer study has suggested that although there is an inverse link between cancer and fruit and vegetable consumption, this link is weaker than might have been expected (Benetou et al, 2008).

However, it has been estimated that eating at least five portions of fruit and vegetables a day could reduce the risk of deaths from chronic diseases such as cardiovascular disease and cancer by up to 20% (Department of Health 2000). Fruit and vegetables can also displace high fat foods from the diet, helping to prevent obesity, and therefore conditions exacerbated or caused by obesity (Cox et al. 1998).

1.2.5) *The effect of childhood diet on future bone mineral density*

Adolescence is the life stage with the greatest increase in bone mineral density (Holick & Dawson-Hughes 2004). Diet (along with weight-bearing activity) can reduce the risk of osteoporosis later in life, by maximizing the density of bone laid down before the balance tips in favour of bone resorption. Studies on early diet and later bone mineral density (and therefore osteoporosis risk) demonstrate a benefit from consumption of milk in childhood and adolescence (Sandler et al. 1985), and adolescent fruit and vegetable consumption intake, on current bone mineral density (McGartland et al. 2004), as well as that in older women (New et al. 2000).

Milk drinking decreases when children reach the teenage years (Gregory & Lowe 2000), when sugar-sweetened drinks appear to displace it from the diet (Harnack et al. 1999; Mrdjenovic & Levitsky 2003), reducing their calcium intake and thereby increasing their osteoporosis risk in later life (Sandler et al. 1985). The cola drinks frequently consumed by

adolescents have also been found to be associated with increased fracture risk in girls (Wyshak & Frisch 1994).

1.3) The Scottish context – Scotland's poor health record in comparison with the rest of the UK and Europe, for adults and children

Among the developed countries, Scotland has a particularly poor health record. Even when matched with their English counterparts of similar socio-economic status, Scots are relatively less healthy in terms of a range of indicators, including age-standardised mortality, as well as several specific disease outcomes (NHS Scotland 2005). Scotland is placed near the top of league tables for major diseases (The Scottish Office 1999), and has a poor life expectancy in comparison with other northern European countries, including the rest of the UK (Hanlon et al. 2001). The situation is improving, and Scotland no longer heads the list of countries with the highest CHD rates, and between 1995 and 2003 mortality rates for CHD and stroke fell by more than a third (Hanlon et al. 2001). However, even though the country's health is improving, it is still faring less well than comparable countries (such as many of its neighbours in Western Europe) which are outstripping Scotland in terms of life expectancy and diseases including cardiovascular disease and certain cancers, especially lung cancer (NHS Scotland 2005). Since overtaking heart disease in 1999, cancer is now the number one cause of premature death in Scotland (Scottish Executive Health Department 2001). Cancer rates in Scotland reached a peak in 1980, and though there has been a decline in mortality and increase in survival since then, the situation in Scotland remains worse than in England and Wales (Scottish Executive 2006b).

Scotland's level of obesity is second only to the USA's among OECD countries, with 22% of men and 24% of women obese in 2003 (Grant et al. 2007), costing the NHS in Scotland an estimated £171m in 2003 (Walker 2003). Obesity, especially central or visceral obesity, increases the risk of several serious diseases, including type 2 diabetes, hypertension, cardiovascular disease, ovarian cancer and osteoarthritis. Central obesity is also increasing in Scotland. Between 1995 and 2003 the proportion of men with a waist

circumference over 102cm rose from 14.4% to 25.3% of men, and the proportion of women with waists measuring over 88cm from 19.4% to 34.3%. Since the International Diabetes Federation produced stricter definitions of central obesity (94cm for men and 80 for women), the situation in Scotland is even more critical (Scottish Executive 2006b).

Although conditions such as cardiovascular disease and cancer are associated more with adulthood than youth, Scottish children show high levels of overweight and obesity, predisposing them to the diseases mentioned above, in the future. Chinn & Rona's study (2001) found childhood overweight and obesity levels to be rising faster in Scotland than elsewhere in the UK. However, in more recent years the trends in Scottish children's prevalence of overweight and obesity have become less clear-cut. The prevalence of overweight and obesity has been increasing among Scottish children, at least during the period between 1998 and 2008 where boys are concerned (Scottish Government 2010c). However, a sharp downturn in overweight and obesity prevalence among boys appeared with the 2009 figures (Scottish Government 2010c). It is not known whether this, or the 2008 data, could be an anomaly, and the authors of the Scottish Health Survey point out that once the complete set of data for the period 2008 – 2011 is available, it will be possible to conduct a more sophisticated analysis of the year on year trends. Where girls are concerned, there has been no statistically significant change in overweight and obesity prevalence since 1998. The figures for overweight and obesity for 2009 were 29.4% in boys and 27% in girls. For comparison, the 2008 figure for boys was 36.1% (Scottish Government 2010c).

Scottish children's dental health is the worst in the UK, and a large survey on Scottish children's sugar intakes found that 74% of 12 – 17-year olds have been treated for dental decay (Sheehy et al. 2008). By the age of 14, 68% of Scottish children have suffered from dental caries (NHS Scotland 2002), the highest figure in the UK (Walker et al. 2000). A consultation on children's oral health in Scotland (NHS Scotland 2002) concluded that the fact that Scottish children have the highest level of dental erosion in the UK is directly linked to their high consumption of acid drinks, including carbonated and sugar-sweetened drinks.

1.3.1) The general characteristics of Scottish children's diets

The average Scottish adult's diet is known to be poor. However, from now this literature review will concentrate on nutrition in children, and the following section of this review will be limited to studies considering young teenagers (similar to the age range of the present study), selected results from which are presented in Table 3.

Children and adolescents in Scotland appear to consume diets less consistent with current healthy eating guidelines (such as dietary reference values, Government guidelines for fruit and vegetables (Department of Health 2003a; Department of Health 2003b), and the targets of the Scottish Diet Action plan (Scottish Executive 1996)) than those in the rest of the UK, being less likely to eat cereals, white fish, green beans and leafy green vegetables (Gregory & Lowe 2000). The Scottish Diet report (Scottish Office Department of Health 1993) included details of the poor diets of Scottish schoolchildren, who were eating diets too high in fat, NMES and sodium, and deficient in several vitamins and minerals. Children in Scotland show unhealthier eating patterns than their counterparts elsewhere in the UK. Eleven percent of Scottish children skip breakfast, compared with a UK average of six percent (Gardner Merchant 2007). Family meals are associated with increased dietary quality (Burgess-Champoux et al. 2009), and 24% of Scottish children help themselves to food from the fridge to provide their 'evening meal' (the highest statistic for any region) (Sodexo 2005), compared with only 5% for the UK overall. Only 45% of Scottish children (the lowest regional statistic) have a sit-down evening meal with others, compared with 60% for the UK overall (Sodexo 2005).

Several Scottish studies considered eating behaviour, intake of foods and food groups in children. A study of 11 – 13-year-old schoolchildren carried out in different regions of Scotland (Seaman et al. 1997) reported that their nutritional knowledge was generally sound, but not put into practice, and that girls were more concerned about their diets than boys. A study of 3rd year secondary schoolgirls in Glasgow (Cresswell et al. 1983) noted their high snacking incidence and low intake of fruit and vegetables, and also that their considerable purchasing power enabled them to exercise reasonable choice over their food intake. A later study also noted Scottish children's frequent snacking – a mean total of

2.8 snacks per day (mainly soft drinks, crisps, biscuits, sweets/chocolate, though fresh fruit was consumed in summer), was seen in a study of 15-year-olds in 1987 (Anderson, MacIntyre, & West 1993; Anderson et al. 1994), which also noted that the young people ate more crisps and biscuits than adults, and less wholemeal bread. However, snacking behavior per se appears not to be linked with poorer nutrient intakes or 'nutrient dilution' (Drummond et al. 1995). The studies by Anderson et al. also mentioned other aspects of the children's eating patterns, with 21% sometimes skipping lunch, and 36.2% having takeaway meals once or more per week.

Scottish children obtain most of their dietary energy from carbohydrate foods, though these tend to be the highly refined and sugary variety - the food groups contributing the highest proportion of their total energy intake are biscuits, cakes and pastries (9%) followed by bread excluding wholemeal (8%) (Sheehy et al. 2008). A UK-wide study of 13 – 14-year-olds (Hackett et al. 1997) found Scotland to have the lowest intakes of wholemeal bread and high-fibre breakfast cereals.

Scottish children and adolescents' diets also appear to be particularly high in high-sugar foods, and are even higher in sugar than the UK children's average (Gregory & Lowe 2000). The main contribution to Scottish children's NMES intake is obtained from non-diet soft drinks (17% of NMES intake), along with confectionery (12%) and biscuits, cakes and pastries (12%) (Sheehy et al. 2008), and the World Health Organization's *Health Behaviours of School children* (HBSC) report published in 2000 (Vereecken & Maes) reported one of the highest daily consumptions of chocolate and sweets, in Scottish youngsters compared with other European countries, particularly in the 11 – 13 age group. A later *HBSC* report found Scotland in the top four countries for fizzy drinks and sweets intake (Vereecken et al. 2004). Consumption of soft drinks by children was found to be higher in Scotland than the rest of the UK (Crawley 1997), and Scottish children ranked 2nd in the 35 countries included in the 2001/2 *HBSC* study of children's health behaviours (Alexander et al. 2004), with 55.9% of boys and 45.2% of girls aged 15 drinking soft drinks at least once daily. A study by Crawley (1997) found Scottish teenagers consuming more fizzy soft drinks (and also chips and white bread) than their counterparts elsewhere in the UK, a finding corroborated by the NDNS (Gregory & Lowe 2000). The 2003 *Scottish*

Health Survey (Bromley et al. 2003) reported that 47% - 73% (depending on socio-economic status) of children ate sweets/chocolates daily, and 30% - 62% drank non-diet soft drinks daily. Thirty-seven to 67% also ate crisps/savoury snacks daily (Bromley et al. 2005). The 2003 *Scottish Health Survey* reported that 32% of boys and 25% of girls consumed sugary drinks daily, a statistic that increased between the Primary 7 and Secondary 2 school years before leveling off.

Intake of fruit and vegetable intake, as well as many other low-fat foods, is also low among Scottish children, with Scottish children having lower consumption of skimmed milk, non-fried potatoes, carrots and green vegetables than the rest of the UK (Gregory & Lowe 2000). Scottish children's low intake of fruit and vegetables is of particular concern; a study of 10 - 11-year-old Scottish children (Wrieden 1996), found that only 37% ate vegetables (excluding potatoes), and 67% ate fruit, daily. Just 25% consumed three or more portions a day, with the mean intake being 2.3 portions. Crawley's study (1997) of Scottish 16 – 17-year-old's diets also noted that 34% of the teenagers ate no fruit during the 4-day study period, and 20% no vegetables. This study also noted that Scottish teenagers' diets (compared with the rest of the UK) were lower in NSP and retinol equivalents, and (in boys) folate; a finding which the subjects' low fruit and vegetable intakes may have contributed to.

A survey of Scottish children's sugar intakes commissioned by Food Standards Agency Scotland (FSAS) (Sheehy et al. 2008) also investigated other aspects of children's diets and found fruit and vegetable intakes of 52g of vegetables and 133g fruit (a total of 185g), which is below the Government recommendation (Department of Health 2003a) of five portions (the equivalent of 400g) daily.

1.3.2) A review of studies on Scottish children's energy and nutrient intakes

Although the NDNS for children aged 4 – 18 (Gregory & Lowe 2000) is generally regarded as the definitive survey on UK children's diets, and uses rigorous methodology (7-day weighed intake), the Scottish component of the survey was comparatively small, with less

than 200 participants. Of these only a small proportion would have been of the age considered by the present study, i.e. 11 – 14 years.

The NDNS for children found Scottish girls to have significantly lower intakes of haem and non-haem iron than those living elsewhere in the UK (Gregory & Lowe 2000), a finding supported by other Scottish studies (see below). Scottish girls' folate intakes were also found by the NDNS (Gregory & Lowe 2000) to be significantly lower than the other UK regions; this nutrient is particularly important once females reach reproductive age, due to its effect in reducing the risk of neural tube defects in the baby if the girl or woman becomes pregnant.

A longitudinal study was conducted by Durnin et al (1974) involving the collection of 7-day weighed intake study of the food and nutrient intake of far more children than those surveyed in the NDNS: 192 14-year-old children in 1964, repeated in 1971 on 419 children of the same age. However, the data for this study was collected in 1964, and it would be expected that children's food preferences, and the foods available to them, would have changed significantly since then, making the findings less relevant to the present study.

The Department of Health survey on *The Diets of British Schoolchildren* (1989), with data collected in 1989, included 252 children from Scotland (155 aged 10 – 11, 97 aged 14 – 15). Seven-day weighed intake data was collected, providing good validity though perhaps compromising compliance and altering habitual behaviour. However, it must again be noted that this is a comparatively old study, and 21 years have elapsed between the study and the preparation of this review.

In 1990 McNeill et al (1991) collected 7-day weighed intake data from 90 first-year secondary school children with a mean age of 12. The effect upon behaviour of 7 days of potentially onerous food-weighing has already been mentioned, and the authors of this study noted a decline in interest and diligence of recording over the period of the study.

A much larger and more recent survey, with 1,431 Scottish participants aged 3 – 17 years, was commissioned by Food Standards Agency Scotland (FSAS) in 2005 (Sheehy et al.

2008). This study was conducted in an attempt to fill in some of the gaps not covered by the NDNS, and concentrated on sugar intake, but also covered intakes of energy, total fat, SFA, NSP, calcium and iron. Children's mean total fat intake was found to be 32.9% of dietary energy, with 13.8% of their dietary energy coming from saturated fats, a figure which exceeds the recommendation of no more than 10% (Department of Health 2003b). Carbohydrate and protein contributed 53.6% and 13.1% of food energy respectively, and the average NMES intake of 3 – 18-year-olds provided 17.4% of dietary energy, with intake increasing with age (providing 19.1% of dietary energy in the 12 - 17 age group). These findings exceeded the recommendation of no greater than 10% of dietary energy (Department of Health 2003b), and were similar to those of the NDNS (Gregory & Lowe 2000) and the Low Income NDNS (Nelson et al. 2007a).

While intakes of most micronutrients in the FSAS Survey of sugar intake among children in Scotland increased with age, that for calcium decreased (along with intake of milk and other dairy products), though mean calcium intake remained above the RNI for all age groups. Also, although mean iron intake was above the recommended level in younger children, it fell below the recommended level in older children, particularly older girls (Sheehy et al. 2008), putting them at risk of iron deficiency anaemia.

This FSAS sugar survey (Sheehy et al. 2008) utilized food frequency questionnaires followed by interview. To assess the validity of the FFQ, a 4-day non-weighed diet record, and a 24-hour multiple pass recall, were completed by separate sub-samples of the study population. When the results obtained by FFQ were compared with those obtained by 4-day estimated intake or 24-hour recall, none of the nutrients considered in the present study (and therefore considered in this literature review) showed a significant difference of $p < 0.001$ for the 3 – 11-year-old age group. When the 12 – 17-year-old age group was considered, there was a p value of > 0.001 for NMES, NSP and calcium intakes, suggesting that data for these nutrients might have lower validity.

Table 3 (following page) shows selected results of dietary intake studies of children in Scotland. Data in the table is confined to subjects in Scotland, of a comparable age to that considered by the present study. The studies may also have involved children elsewhere in the UK, and younger and/or older children.

Table 3 (part 1): Scottish studies considering whole-day nutrient intakes of young teenagers.

Author	N	Study year	Age	Sex	Method	E (kcal)	Fat (g)	SFA (g)	NMES (g)	Total sugars (g)	NSP (g)	Vit A (ug)	Fol (ug)	Ca (mg)	Fe (mg)
Durnin et al, 1974	102	1964	14	M	7DWI	2,795	119							1,210	
	90			F		2,270	101							938	
	198	1971	14	M		2,610	115							1,020	
	221			F		2020	93							796	
Dept of Health, 1989	457		10-11	M	7DWI	2,051	87.2					620		880	9.8
	427			F		1,825	79.0					590		740	8.6
	56		14-15	M		2,484	106.6					900		960	11.9
	42			F		1,975	85.7					510		720	
Gregory, J. & Lowe, S., 2000	237	1997	11 – 14	M	7DWI	1,876	77.2	30.3	90		11.6	558	245	799	10.8
	238			F		1,515	67.2	26.2	73		10.2	467	205	641	8.8

Table continued on following page.

Table 3 (part 2): Scottish studies considering whole-day nutrient intakes of young teenagers

Author	N	Study year	Age	Sex	Method	E (kcal)	Fat (g)	SFA (g)	NMES (g)	Total sugars (g)	NSP (g)	Vit A (ug)	Fol (ug)	Ca (mg)	Fe (mg)
McNeill, G. et al, 1991 *	18	1990	12	M	7DWI	2,140	93			117	16	494	105	822	10
Sheehy, C., et al, 2008 **	1,391	2005	3-11	F		1,944	85			110	15	510	90	767	10
				M/F	FFQ	1,733	67.9	29.7	80		13.0			999	9.5
				M/F		1,814	70.7	30.3	86		12.5			1,05	9.1

N = number of children in the study, of the age in the table (study may have considered older and younger children also).

7DWI = 7 day weighed intake. 3DEI = 3 day estimated intake. 4DEI = 4 day estimated intake. DH = Diet history. 24HR = 24-hour recall

* This study (McNeill et al, 1991) measured 'sugar', which is assumed for this table to represent total sugars

** This study (Sheehy et al, 2008) also conducted 4DEI and multiple pass 24HR for subs-samples of the total sample

1.4) A history of Scottish nutrition policy

Much of the legislation and strategies regarding nutrition in Scotland is distinct from that concerning and governing the rest of the UK. In the early 1990's, with rising awareness of Scotland's poor diet, the Chief Medical Officer set up a working group to survey the current Scottish diet, assess its impact on health, and make proposals for improvement. The resulting report, entitled *The Scottish Diet: A challenge to us all* (Scottish Office 1993) highlighted the urgent need for change in Scotland's food and nutrient intake. These concerns were addressed by *Eating for Health, a Diet Action Plan for Scotland*, also known as the Scottish Diet Action Plan (SDAP) (The Scottish Office 1996). This became the framework for improving Scotland's diet, and introduced dietary targets with the aim of reducing diet-related mortality and morbidity, especially that relating to heart disease, cancer, diabetes, and also obesity.

The SDAP's most important target was that of increasing fruit and vegetable consumption, with intake to double to more than 400g per day. Average intake of non-milk extrinsic sugars in adults was not to increase, while average intake of non-milk extrinsic sugars in children was to reduce by half, to less than 10% of total energy. Oily fish consumption was to double to 88g per week. Other targets were set for increases in the intake of bread, breakfast cereal and total complex carbohydrates, and reduction in the intake of fats, saturated fatty acids and sodium.

As well as setting targets, the SDAP included practical proposals for instigating change, concentrating on areas where barriers to progress were fewest, and the potential for benefit greatest. For example, consumer tastes would be shaped and demand (and supply) for healthier food increased, and the Scottish Community Diet Project (SCDP) was established. Nutritional awareness was to be improved through education and labeling, and improvements were to be made in public sector catering.

In terms of policy, following the publication of the Consultation *Working Together for a Healthier Scotland* (The Scottish Office Department of Health 1998), Scotland's poor record for diet-related illness was first recognized in the White Paper *Towards a*

Healthier Scotland (The Scottish Office 1999), which also reinforced Government commitment to the SDAP, and increased funding to £2 million over the following three years. (Later, in the years following Devolution, annual Government funding for improving public health increased significantly, from a figure of between £1 million and £2 million for 1996–2000, jumping to £24 million in 2000–2001 and £66 million in 2003/04/05 (Lang et al. 2006).

Devolution in 1999, and the new Scottish Government, brought many changes, including the establishment in 2000 of a Scottish arm of the Food Standards Agency, with a remit including public health nutrition. A Food and Health Co-ordinator for Scotland was appointed in 2001. Later came further increases in Government funding on public health, including the specification of nutritional standards for school meals (Scottish Executive 2003b), and *Improving Health in Scotland: The Challenge 2003* (Scottish Executive 2003a) committed the Scottish Executive to the support and implementation of the SDAP until 2010, beyond its original timescale of up until 2005.

In April 2003 the Scottish Executive Health Department and the Food Standards Agency Scotland established a Working Group on Monitoring Scottish Dietary Targets (Working Group On Monitoring Scottish Dietary Targets 2004) to investigate and report on ways of assessing progress made towards the Scottish Dietary Targets, and advise on surveillance beyond 2005. One of its conclusions was that there is unfortunately no stand-alone dietary survey in Scotland, due to various methodological limitations.

In 2003 Health Scotland was formed by the merger of pre-existent bodies, as a new national level NHS board responsible for health improvement and public health in Scotland. Also in this year the FSAS produced its *Diet and Nutrition Strategy 2003–2006* (Food Standards Agency Scotland 2003), committing to working alongside the Scottish Executive Health Department on monitoring and achieving the SDAP targets. *Eating for Health: Meeting the Challenge*, published in 2004 (Scottish Executive 2004) aimed to augment and add to the SDAP.

The Scottish Food Council was established in 2005 (Lang et al. 2006) to ensure the implementation of dietary and nutritional change in Scotland; also in 2005, Health

Scotland appointed an independent review panel to examine the progress towards the SDAP targets over the preceding years (Lang et al. 2006). Areas of success noted by the panel included an increase in breastfeeding, and small but encouraging outcomes from initiatives including free fruit in schools and local initiatives addressing inequality. Another positive result was the guidance on the nutritional content of school meals provided by *Hungry for Success* (Scottish Executive Expert Panel on School Meals 2002). However, the panel reported that although considerable progress had been made towards the overall SDAP recommendations, little effect was seen in Scotland's actual food consumption patterns. The only target where progress was seen was that for total fat, with a reduction from 40% of total energy intake to 38%, but even this fell short of the recommendation of 35%. The change in saturated fat intake was negligible, from approximately 15.6% to 15.2% of food energy, well short of the 11% target. Also, there was no progress towards the targets to increase intake of complex carbohydrate, breakfast cereal and oily fish.

Greater areas of concern were the target areas where the situation worsened. The NMES intake, rather than remaining stable for adults and reducing for children, actually increased, and potato intake decreased by the amount (25%) by which it was intended to increase. Bread consumption overall fell by 12% instead of increasing by 45%, with brown/wholemeal bread consumption falling by 25%, and the consumption of potatoes fell by 25% instead of increasing by 25%. Only minimal progress had been made on increasing consumer demand for fruit and vegetables, and providing basic nutrition training for those working in the food and hospitality industries. The panel partially blamed the lack of progress, and indeed regression on some targets, on changes in eating patterns, such as the consumption of more meals outside the home, and the increasing popularity of soft drinks, snacks and confectionery. The conclusion of the report was that Scotland's diet remained unacceptable, and that improvement had been too slow, and patchy at best. Particularly in light of rapidly rising obesity levels, radical change was needed.

The Scottish Government's *Better Health, Better Care Action Plan* was launched in 2007 (Scottish Government 2007), pledging extra funding of £11.5m over three years to help tackle obesity (particularly in children) through diet and exercise initiatives, and

proposed the launch (for 2008) of a Food and Health Delivery Plan. In 2008 the Scottish Government *published Healthy Eating, Active Living* (Scottish Government 2008c) and pledged an additional £40 million of new money (to make a total of £56 million) to spend on diet, physical activity and promoting healthy weight. Most recently, the Scottish Government published a 'route map' for preventing overweight and obesity in Scotland (Scottish Government 2010a), setting out a range of population-level actions as well as plans for monitoring progress.

1.5) An introduction to the potential of school meals to improve children's overall nutrition

Young people spend more time in school than in any other single activity, and schools are in a unique position to educate and motivate young people regarding healthy eating. In addition, school children can be reached while their eating patterns are still developing, and when healthy behaviours are more easily acquired than in adulthood.

Health, education and nutrition support and enhance each other; for example good nutrition supports educational potential, and vice versa (World Health Organization 1998). In turn, nutrition education, and the provision of nutritious food and a supportive environment for children to try new foods, can encourage good lifelong nutrition. By extension, whole families can benefit, when children take home and share their healthy attitudes, acting as 'ambassadors' for good nutrition.

Healthy school lunches have the potential to make an important contribution to children's nutrient intakes, and therefore their health both now and in the future. This is the main meal of the day for many children (Crawley 2005a), and The National Diet and Nutrition Survey of Young People aged 4 to 18 years (Gregory & Lowe 2000) reported that in 11 – 18-year-old children, school meals contribute between one-quarter and one-third of the daily intake of energy, fat, dietary fibre, iron, calcium, vitamin C and folate.

However, the school environment is not necessarily positive in terms of nutritional benefit. An Australian study notes the concept of 'Obesogenic schools', where

children's intake of calorific foods and benefits were high, and energy expended minimal, leading to a state of positive energy balance (Bell & Swinburn 2004). Alarmingly, the study also noted that energy-dense foods were most commonly consumed at school (whether as packed or school lunch).

An important first step would appear to be ensuring that nutritious food is available to children in the school canteen. However, an additional problem arises when children start secondary school, and the variety of food sources available to them during the school day expands, giving them additional choices, and not all of them healthy. As well as the school canteen (often self-service), there may be tuck shops, vending machines, snack vans, local shops, plus food brought from home. As the choice rests with the child, it becomes more important to teach them not only how to select healthy options, but also the relevance of those choices to their lives.

1.5.1) *A history of school meals in the UK*

The Education Act of 1980 and the 1980 Education (Scotland) Act abolished national nutritional standards, which were devolved to a local level. Gradually the concept of a 'school dinner' involving little or no choice was replaced by a cafeteria system, which is now the norm, almost exclusively so in secondary schools (Brannen & Storey 1998).

In 1992, the Caroline Walker Trust (CWT) published the first nutrient-based school meal standards for the UK (The Caroline Walker Trust 1992). Maximum values were recommended for calories, fat, saturated fat, sodium and sugar, with minimum values for fibre, protein, iron, zinc, calcium, vitamins A and C, and folate, and portions of fruit and vegetables. Oily fish was to be served at least once a week, and fried or processed vegetable products no more than weekly. The recommendations were for an 'average meal', over a period of one week or more, and were based on the dietary recommendations of COMA (Department of Health 1991).

The same year, the 1992 *Health of the Nation* White Paper (Department of Health 1992) made several recommendations, including that schools should become 'Health

Promoting Schools' (HPS) as defined by the World Health Organization. The concept of the Health Promoting School is defined as "a school constantly strengthening its capacity as a healthy setting for living, learning and working" and the World Health Organization declares that "The extent to which each nation's schools become Health Promoting Schools will play a significant role in determining whether the next generation is educated and healthy" (World Health Organization 1998).

Although Health Promoting Schools focus on a variety of issues, including physical activity and mental health, nutrition remains a cornerstone, as well as an area where interventions have been seen to be most effective (World Health Organization 1998). Health Promoting Schools offer opportunities for healthy eating choices by providing a wide variety of healthy foods, based on nutritional guidelines where available, with minimal exposure to foods of low nutritional value, in a pleasant eating environment. Schools are also encouraged to work with vendors outside and nearby the premises, to encourage the school's health promotion efforts and avoid providing 'competing' unhealthy options. Nutrition education (theoretical and practical), and nutrition-related activities such as food experiments and growing food, are also highlighted. This kind of whole-school food policy is also endorsed by the Caroline Walker Trust's guidelines for food in schools (Crawley 2005a).

The UK joined the European Network of Health Promoting Schools in 1993, with each country taking a slightly different approach (Health Education Board for Scotland et al. 1996; Crosswaite et al. 1996). Since then, encouraging progress in promoting healthy eating has been made (Bowker et al. 1998), and over the following years, several White Papers reiterated the Government's commitment to the concept of Health Promoting Schools (Passmore & Harris 2004).

An Education and Employment select committee inquiry in 1999 recommended the introduction of nutrient-based standards based on the CWT guidelines, which would be monitored by Ofsted. That same year, the Department for Education and Skills and the Department of Health launched the National Healthy Schools programme (NHS & Department for Children Schools and Families 2009), and all schools were expected to achieve healthy school status by 2009 (Crawley 2005b).

The Education (Nutritional Standards for School Lunches) Regulations 2000 (Department for Education and Skills 2000) set out minimum nutritional standards for school lunches in England, with equivalent measures in Wales (Crawley 2005b). In 2001 the Department for Education and Skills (DfES) introduced new food-based National Nutritional Standards based on these standards. However, a report commissioned by the Food Standards Agency and the DfES (Nelson et al. 2004) showed that the nutritional standards coupled with the current school meals system were insufficient to encourage children to select food combinations to contribute to healthy diet.

In 2005, the National Heart Forum collaborated with the CWT to update the 1992 guidelines to reflect new scientific findings and advice (Crawley 2005a), and continued to assert that both food-based and nutrient-based standards should be compulsory. The standards were expanded to include all foods and drinks served across the school day, such as those from vending machines and tuck shops, which should restrict foods and drinks high in fat, sugar or salt. The report also recommended that schools provide guidance to parents that a packed lunch should contain a starchy food such as bread, some meat, fish or an alternative such as cheese or egg, and at least one portion of fruit and one portion of vegetables, while limiting soft drinks, confectionery, high-fat, high-salt and high-sugar foods.

1.5.2) *A history of school meals in Scotland, after Scottish devolution in 1999*

With Scottish devolution in 1999, education was one of the issues which become devolved, with the consequent divergence of Scottish school meal policy from that of the rest of the UK.

In 2002 the Scottish Executive convened an expert panel on school meals, which made a series of recommendations to improve the nutritional quality and take-up of school meals in Scotland in its report *Hungry for Success – A Whole School Approach to School Meals in Scotland* (Scottish Executive Expert Panel on School Meals 2002),

which committed £63 million over three years. *Hungry for Success* also included the introduction of new Scottish Nutrient Standards for School Lunches (Scottish Executive 2003b), which were based on the 1992 CWT guidelines, and would become compulsory in all special and primary schools by 2004 and all secondary schools by 2006. The new standards were nutrient-based as well as food-based, a first for the UK. In common with the CWT guidelines, the Standards were for nutrient content averaged over a school week, rather than a single day, and are shown in Table 4.

Table 4: Nutrient Standards for School Lunches for pupils in Secondary Schools in Scotland

NUTRIENT	RECOMMENDATION	AMOUNT
Energy	30% of EAR	646Kcal
Fat	Not more than 35% of food energy	25.1g
SFA	Not more than 11% of food energy	7.9g
Carbohydrates	Not less than 50% of food energy	86.1g
NMES	Not more than 11% of food energy	18.0g
Fibre/NSP	Not less than 30% of calculated reference value	5.2g
Protein	Not less than 30% of RNI	13.3g
Iron	Not less than 40% of RNI	5.9g
Calcium	Not less than 35% of RNI	350mg
Vitamin A (retinol equivalents)	Not less than 30% of RNI	185ug
Folate	Not less than 40% of RNI	80ug
Vitamin C	Not less than 35% of RNI	13mg
Sodium	Not more than 33% of SACN recommendation (Scientific Advisory Committee on Nutrition: 2003)	786mg
Fruit/vegetables	1/3 of 5 portions per day	2 portions

Source: (Scottish Executive 2003b)

Key to Table 4:

EAR = Estimated Average Requirement RNI = Reference Nutrient Intake

While a school lunch was expected to provide approximately one-third of a day's nutrient intakes, the levels the SNSSL recommended for several vitamins and minerals for which minimum values were recommended were set at higher levels due to the importance of these nutrients to children's health, and the typically low intakes seen. The standards required lunches to provide 35% of the RNI for calcium and vitamin C, and 40% of the RNI for iron and folate. The *Schools (Health Promotion and Nutrition) (Scotland) Act 2007* (Scottish Parliament 2007) built on *Hungry for Success* in requiring schools to ensure that the food and drink they provided complied with nutritional requirements.

New standards, *The Nutritional Requirements for Food and Drink in Schools (Scotland) Regulations*, were introduced in 2008, (Scottish Government 2008b). The nutrient-based standards were updated, with the addition of a standard for zinc, due to public health concerns regarding children's zinc intakes, and a phased approach to the maximum level set for sodium, to make this more achievable for schools. In addition, while previously, the minimum levels of several nutrients for which the standards were minimum values, the standard had been set at 30%, 35% or 40% of the RNI, the new Regulations saw all the minimum standards set at 30% of the RNI.

The Regulations stated that a choice of at least two types of vegetables (excluding potatoes) and two types of fruit (not including fruit juice) must be provided every day as part of the school lunch, and oily fish at least once every three weeks. Because previously children had been able to consume high-salt, high-fat foods as part of their canteen lunches, albeit sometimes with limited frequency, the limitations on foods allowed to be served as part of school lunches were also tightened. Salt was not to be offered on tables, deep fried foods (including chips) were limited to a maximum of three times weekly (with chips served only as part of a meal), confectionary of all kinds was banned from lunch menus, as were savoury snacks with the exception of savoury crackers, oatcakes and breadsticks. Confectionary included all chocolate products and products including chocolate, sweets, cereal bars, and sugared or yogurt-coated fruit or nuts. Cakes and biscuits were not to be included as a substitute for confectionary.

Regarding drinks, fizzy drinks (including diet versions), sweetened fruit juice drinks, and cordials, were banned.

Because children may also purchase food from the school at times other than lunchtime, the Regulations were expanded to cover foods and drinks served at times other than the lunchtime break, such as breakfast clubs, vending machines, tuck shops and morning break snack services. Fried foods and confectionary were banned from foods covered by this part of the Regulations. Limitations on the nature of savoury snacks were less stringent for food served at times outside the lunch period, though maximum values for pack size, total fat, saturated fat, sodium and sugar were set.

The Regulations came into force in August 2008 for primary schools and August 2009 for secondary schools. However, Fife Council pre-empted the deadline, introducing the parts of the new Regulations for Secondary schools concerning the lunch menu from August 2008 (Fife Council 2009), shortly after the present survey was conducted.

However, although the new Regulations on foods that can be served in schools are certainly an improvement upon those formerly in place, they cannot dictate the foods children consume during school hours – pupils can still bring in food from home, or purchase it outside school, lessening the potential benefit to the school population as a whole, since only those consuming school meals will gain its nutritional benefits. For this reason, the present study, and this literature review, will also investigate packed lunches, and those purchased by children outside school.

1.6) The different lunch options available to children – canteen, packed and street lunches – and changes in their take-up

Over the years, children at secondary schools have been afforded more freedom regarding leaving school premises at lunchtime, and consequently the nature of the lunches consumed has changed. While previously, schoolchildren's lunch options would have been limited to a school dinner, a packed lunch from home, or returning

home for lunch, now increasing numbers of pupils purchase their own lunchtime food outside school, referred to for the purposes of the present study as 'street lunches'.

Much previous research on children's lunchtime food intake omitted lunch options apart from canteen or packed lunches (Durnin et al. 1974; Nelson et al. 2004; Whincup et al. 2005; Gould et al. 2006) suggesting that street lunches were not considered significant when these studies were conducted. Some studies considered pupils going home for lunch (Richardson & Lawson 1972; Nelson & Paul 1983).

However, even in some early research on school day lunches, a small proportion of children were observed to have street lunches, and these are examined in some studies (Richardson & Lawson 1972; Department of Health 1989; Seaman et al. 1997; Consumer Association 2003).

Over time, the proportion of children consuming street lunches has increased from a low baseline. In the late 1990s, the Gardner Merchant survey entitled *What are today's children eating?* (1998), found that street lunches were by far the least popular lunch option, and that children not consuming canteen lunches tended to have packed lunches instead. The survey noted where the children not taking school lunches obtained their lunch from, finding that 79% had packed lunches, 10% bought hot food from shops, 5% sometimes went home, 4% bought cold food from shops, and 1% skipped lunch (therefore 14% of this group bought a 'street' lunch outside school).

A Consumer Association survey of 246 children (Consumer Association 2003) reported that 30% of 15-year-olds sometimes bought their own lunch outside school premises, mainly for reasons of speed, though some children reported preferring the foods available outside school.

By 2005, the Sodexo survey found street lunches to have increased at the expense of canteen meals. This survey included 1,131 secondary school children (71 in Scotland) and found the average child to have a school meal 2.7 times per week, with 33% never having a school meal. The survey found Scottish children less likely to have a school meal (2.1 times per week), with 46% of Scottish children never having a school meal. In

the Sodexo survey, of the children not having a school meal, 73% brought a packed lunch, 13% bought hot food from a local shop, 7% bought snack food from a shop, 4% sometimes went home for a meal, 2% bought food from a snack van outside school, 1% bought lunch from a school vending machine, and 1% had no lunch. The proportion of non-school lunch eaters in Scotland having a packed lunch was much lower than elsewhere in the UK, at 34%. Also, significantly more Scottish children chose the street lunch option, with 30% buying hot food from a shop, 13% buying snack food from a shop, and 9% purchasing from a van. A total of 52% of children in Scotland not taking canteen lunches had street lunches, compared with 23% in the UK overall.

The Food Standards Agency Scotland's Secondary analysis of the Survey of Sugar intake among Children in Scotland (McNeill et al. 2009a) utilised data from 2006, and found street lunches to be the most popular lunch option among secondary school children aged 12 – 17 years, with 48% consuming street lunches, 34% consuming canteen lunches and packed lunches the least popular option, at 18%.

The finding that street lunches are now the most popular option was supported by a study of 322 children in two secondary schools in London (Sinclair & Winkler 2008). This study examined food purchased by children from shops around their school, on the way to and from school, and during their lunch break. The researchers found that while 80% of pupils purchased food from shops, only two-fifths visited the school canteen (the figures not adding up to 100% indicating that children did not confine themselves to one lunch option exclusively). Not all of the children in the study were allowed out of school at lunchtime (one school only permitted sixth form pupils to do this), but street food did make an important contribution to the vast majority of children's diets. The most serious nutritional concern regarding the street food was its high sugar content.

Detailed annual data is collected in Scotland on the numbers of children purchasing canteen lunches on a single survey day. Table 5 shows the numbers and percentages of pupils in Scotland taking canteen lunches in the years between 2006 and 2009. The proportion of secondary school children in Scotland taking school lunches in 2007 (the year when the present study was conducted) was 44.9%, slightly higher than the previous years (Brannen & Storey 1998; Scottish Executive 2007a). However, in

following years, take-up fell (Scottish Government 2009), followed by a slight upturn in 2010 (Scottish Government 2010d).

Table 5: Secondary school pupils in Scotland taking canteen lunches, 2006 – 2009

Year	Pupils on school roll	Pupils present on census day	Pupils taking school lunch	% of pupils present taking school lunch	Change in uptake from previous year
2005	308,326	271,756	124,622	45.9	
2006	305,148	268,987	116,815	43.4	-1.5%
2007	302, 638	267,710	120,192	44.9	-1.5%
2008	297,552	264,570	113,379	42.9	-2.0%
2009	294,155	265,302	103,915	39.2	-3.7%
2010	294,427	266,707	105,564	39.6	+0.4%

Source: Scottish Government 2010d)

Fife (the county where the present study was conducted) has a higher proportion of children taking school meals than Scotland overall (Scottish Executive 2007a; Scottish Executive 2007b). However, Table 6 indicates that Fife experienced a proportionally greater fall in take-up of school meals after 2008, compared with that seen for Scotland as a whole (a fall of 14.1% for Fife, compared with 3.7% for Scotland). In a telephone conversation to St Columba's High School on 9 September 2009, a member of the catering staff attributed this largely to the introduction of the new more stringent lunch standards (in advance of the rest of Scotland), limiting availability of children's favoured foods, and causing them to buy their own food or bring packed lunches.

Table 6: Pupils in Fife taking canteen lunches, 2007 - 2009

Year	Pupils on school roll	Pupils present on census day	Pupils taking lunch	% of pupils present taking school lunch	Change in take-up from previous year
2007	21,351	18,482	10,873	59	
2008	21,008	18,340	10,604	57.8	-1.2%
2009	20,793	17,956	7,841	43.7	-14.1%
2010	20,623	17,948	7,971	44.4	+0.7

Source: (Scottish Executive 2010d)

1.7) A review of studies on children's food choices in the school canteen

A study of Scottish secondary school children and their food knowledge, preferences and lunchtime choices (Seaman et al. 1997), found the foods they 'liked a lot' to be high in fat and sugar: chocolate, chips, crisps and fizzy drinks. Considering their overall food preferences in that study and others, children's preferences in the school canteen are unsurprising, with the most popular main courses being (in order) pizza, pasta, burgers, chicken, and jacket potatoes, and the most popular desserts cakes, buns and ice cream (Sodexo 2005). When asked what foods they wanted schools to provide, pizza once again topped the list, followed by chips and, surprisingly considering their poor intake, fresh fruit (Sodexo 2005).

These lists of favourite canteen foods are supported by results from the Consumer Association survey (2003), which found pizza, chicken nuggets and burgers to be the most popular main courses, with chips and potato smiley faces the most popular starchy carbohydrate accompaniments.

Nelson's study of school meals in secondary schools in England (Nelson et al. 2004) noted the high-fat, high-sugar natures of children's favourite canteen lunch foods. Forty-eight percent of pupils in the study chose high-fat main dishes (including burgers), 48%

chose chips and other potato products cooked in oil, 45% chose soft drinks and 24% chose cakes or muffins. The least popular choices were fruit (2%), fruit juice (3%), and vegetables and salads (6%).

Even if schools are able to provide a healthy menu at the beginning of lunchtime, the lack of choice available at the end can make this very difficult. A survey of secondary school lunches (Nelson et al. 2004) found that while 87% of school menus met nutritional standards at the beginning of lunchtime, only 43% did so when the lunch period ended.

A secondary analysis of the abovementioned study was conducted and comparisons made with the school lunch data from the NDNS for young people (Gregory & Lowe 2000). This secondary analysis of the NDNS (Nelson et al. 2007b) provided an insight into the NDNS lunch data, when children's most popular canteen lunch choices were high-fat and high-sugar foods such as desserts/cakes, fizzy drinks, chips, and other potatoes cooked in fat (48% in secondary school lunches, compared with the 8% recommended by the Food Standards Agency's Balance of Good Health model (Food Standards Agency 2001).

The secondary analysis also suggested that consumption of higher-fat main courses, chips, soft drinks, pasta and other cereals were higher in 2004 than in 1997, and that consumption of sugar/confectionary and savoury snacks was lower. The authors commented that this could be due to a real change in children's food choices, or possibly the change could be methodological in origin; the 1997 NDNS utilised food diaries, whereas the 2004 study was observational.

1.7.1) A review of studies measuring the nutrient content of school canteen meals

An analysis of 533 school meals taken by children in Cambridge in the 1980s (Nelson & Paul 1983) found a mean energy intake of 494kcal, or 23.8% of the EAR. The meals supplied approximately the recommended one-third of the daily requirement for calcium (30.1%) and protein (31.9%), but only 22.2% and 23.8% of the RDA for iron and vitamin

C, respectively. A less recent study of secondary schoolchildren in London (Richardson & Lawson 1972) had found school lunches to contain a mean of 680kcal, or 27% of the daily recommended energy intake. These energy intakes are below the current expected and recommended energy content of a school lunch, which is of one-third of the EAR.

In more recent years, school lunches have tended to exceed the maximum recommendations for nutrients considered unhealthy in excess. Nelson's survey of secondary school lunches (Nelson et al. 2004) found 41% of total energy to be derived from fat, and 14% of total energy from saturated fatty acids, against the Caroline Walker Trust Guidelines of 35% or less energy from fat, and 11% or less for saturated fatty acids. Fourteen percent of the lunches' energy content came from NMES, compared with the Caroline Walker Trust guideline of 11% or less. Reiterating these findings, a study of 8 – 11-year-old boys which collected data by utilizing smart card technology used by children to purchase their lunches found that 59% of canteen lunches failed to meet nutritional standards (Lambert et al. 2005a). Based on the population mean, sugar intakes were higher than recommended, while fibre, iron and vitamin A were lower than the minimum recommendation.

A study of English 11 – 12-year-olds (Gould et al. 2006) gathered data on the nutrient quality of school meals, and noted that the children did not choose the 'optimum' lunch available from the cafeterias, instead picking much less healthy choices. For starch, monounsaturated fatty acids and folate, the availability of rich food sources was the main influence on children's intake, while for other nutrients, children's food choices were the main influence.

1.8) A description of the typical foods found in children's packed lunches

Most children's packed lunches contain a sandwich or filled bread roll. A study of 556 children on behalf of the Food Standards Agency (Jefferson & Cowbrough 2004) found the most popular food items in packed lunches to be white bread sandwiches (found in

62% of lunches) or filled white bread rolls (in 16%). The most popular fillings were ham (31%) and cheese (21%), both of which are relatively high in saturated fatty acids.

The Sodexo survey (2005) found 45% of lunchboxes to contain a meat sandwich (or equivalent, such as a bread roll), 34% one filled with cheese, and 32% with an alternative filling. Fifty-five percent of the packed lunches in that survey contained crisps/savoury snacks, 42% contained a chocolate bar, 32% an apple, 27% a yogurt, 32% a carton of drink, and 20% another form of drink. This is similar to the findings of the Gardner Merchant School Meals Survey (1998), which found the favourite packed lunch foods to be crisps (57%), chocolate bars (39%), a meat sandwich/roll (38%), or a cheese sandwich/roll (37%).

The Food Standards Agency School Lunchbox Survey (Jefferson & Cowbrough 2004) study reported that 71% of packed lunches contained crisps or savoury snacks, 48% contained a dairy item (usually yogurt), and 21% contained a cake or cereal bar. 49% contained fruit, the most popular types being apples and bananas. 91% of the packed lunches included a drink, usually squash (28%), fruit juice (9%) or a carbonated drink (9%). Ready-to-drink fruit drinks provided the largest proportion of sugars in the packed lunches, followed by squash, carbonated drinks, apples, and yogurts.

In conclusion, while sandwiches provide a useful source of starchy carbohydrates for children, it is discouraging to find from the studies above that white bread is preferred over wholemeal, and that high-saturated fat fillings are favoured. Yogurts, which could have provided calcium and protein, were mentioned infrequently, while savoury and sweet snacks, tending to be high in fat and sugar, were much more popular. The popularity of fruit in packed lunches, however, is encouraging.

1.8.1) A review of studies measuring the nutrient content of children's packed lunches

A 1970s study mentioned previously (Richardson & Lawson 1972) found packed lunches to be lower in terms of energy consumed, and also lower in several nutrients - than other lunch options. Packed lunches contained fewer calories than canteen, home

or street lunches, and also the lowest percentage of the RDA for iron (14%) seen among the lunch types, and only slightly more calcium (18% of RDA) than street lunches (which were the lunch type lowest in this mineral in this study).

The Food Standards Agency *School Lunchbox Survey* (Jefferson & Cowbrough 2004) reported that children in Scotland consumed packed lunches that were lower in energy, fat and saturated fatty acids (by weight and percentage of energy), and salt than those elsewhere in the UK, but had the highest sugar content by percentage of energy.

Although it must be noted that it concerned primary school children aged 6 – 11 years, rather than the secondary/senior school children in the present study, another more recent study of found packed lunches to be high in saturated fat and especially sugar (Rees et al. 2008). Another study of primary school children aged 7 – 10 years also found packed lunches to be nutritionally poor, particularly in respect of iron intake, fruit and vegetable consumption, and percentage energy from NMES (Armstrong & Clapham 2007).

1.9) A review of studies measuring the nutrient content of street lunches

Fewer studies have investigated street lunches. A study conducted on London senior schoolchildren in the 1970s (Richardson & Lawson 1972) found street lunches to be the lunch type of most nutritional concern, due mainly to large amounts of sweets, cakes and soft drinks, and consequent high sugar contents (mean 29g). The street lunches were also poor in calcium, containing a mean of only 110mg, or 17% of the RDA.

The secondary analysis of the *Survey of Sugar intake among Children in Scotland* (data collected in 2006) found street lunches to be high in NMES (mean 38g), due in large part to the large amounts of non-diet fizzy drinks consumed (McNeill et al. 2009a).

A pilot study by the author of this thesis (Norris 2005), involving 31 schoolchildren aged 12 - 14 eating street lunches, found statistically significant excesses of dietary energy, and food components considered harmful in excess (fat, sodium, and in particular

NMES, for which the mean intake was twice the SNSSL maximum). All of the vitamins and minerals studied (those considered by the SNSSL), along with fruit and vegetables, were consumed at below recommended levels (statistical significance extremely high, excepting vitamin C, for which the difference was not significant). The range of intakes was extremely broad – for some nutrients the mean intakes were far above or below the SNSSL. Some pupils' lunchtime intakes of one or more of the following nutrients were zero for the study period: vitamin A, vitamin C and folate.

1.10) A review of studies comparing the nutrient contents of canteen, packed and street lunches

A study of primary and secondary schoolchildren in Kent in the late 1960's (Cook et al. 1975) found school canteen lunches to be higher in nutrients than other lunch options, with school lunches also providing a higher proportion of daily nutrient intake than other meals. Children taking canteen lunches also had higher weekday nutrient intakes than other children during term time. This was particularly the case for animal protein, vitamins A and D, and iron.

The view in the popular media has often been that canteen lunches are high in fat and low in nutrients, and packed lunches are healthier than canteen lunches – particularly before the introduction of nutritional targets and standards for meals served in school canteens. A study conducted in the 1970's (Nelson & Paul 1983) also found canteen lunches to contain less of a day's intake of every nutrient except protein and vitamin C, than packed or home lunches.

However, other studies show that the situation is not simple, and that the alternative provided by packed lunches is not necessarily more nutritious. Children's tendency to choose unhealthy foods has already been discussed, and mothers report that children have extensive control over what goes into their lunchboxes (Brannen & Storey 1998), so would be expected to ask for their favourite foods with little or no concern for nutrition.

The Consumer Association survey on packed lunches found them to be higher in fat and sugar, and also in vitamin A, due to the spread used in sandwiches, (Consumer Association 2003) than canteen lunches. The packed lunches contained slightly less fruit and vegetables than canteen lunches, and lower levels of zinc, and fibre (provided in the canteen lunches by baked beans and potatoes).

Richardson and Lawson (1972) found the highest lunchtime energy intakes were from canteen and street lunches (mean 680kcal), followed by home lunches (mean 555kcal) and packed lunches (mean 440kcal). The study also noted the enormous variation in energy intake. Regarding iron content, school and home lunches had the highest intake, followed by street lunches. Packed lunches were poorest in iron, though their lower calorie intake could suggest that they were smaller in quantity of food than the other lunch types. However, street lunches fared worst overall in nutritional terms, due to their high sugar, and low iron and calcium contents.

A recent study comparing the canteen and packed lunches of children aged 6 – 11 years (Rees et al. 2008) suggests that the increased public and Government awareness of the importance of school lunches, and the phasing in of new standards for school meals in England, may have improved the nutrition provided by canteen lunches in comparison to packed lunches, though the canteen lunches still fell short of the targets of 35% of the RNI for calcium. This study found canteen and packed lunches to be similarly calorific, and neither reached the target of 35% of the RNI for vitamin C) but their nutrient contents (and therefore also nutrient densities) differed in other respects. Packed lunches contained approximately twice the amount of sugar found in canteen lunches (mean 28g, or 22% of food energy in packed lunches, compared with 13g, or 11% of food energy in canteen lunches). They also contained 50% more sodium and saturated fatty acids than canteen lunches. In addition, only 8% of packed lunches contained a portion of vegetables, compared with 81% of canteen lunches. However, the packed lunches were more likely to contain fruit (58% of packed lunches contained fruit, compared with 13% of canteen lunches), and were higher in iron and calcium than canteen lunches (though neither canteen nor packed lunches met the target of 35% of the RNI for iron). It must also be noted that the children in this study were at primary school, which is a very different environment from that of the

secondary school children in the present study. The study was included in this review due to the small number of studies comparing the nutrient content of different lunch options.

A secondary analysis of the *Survey of Sugar intake among Children in Scotland* (McNeill et al. 2009a) suggested that packed lunches were the healthiest lunchtime option, though noted that the small sample size for packed lunches ($n = 15$) meant that this finding should be interpreted with caution. One healthy characteristic of packed lunches found by this study was a higher mean fruit content (58g for packed lunches, compared with 32g for street lunches and 6g for canteen lunches). Generally, a greater proportion of packed lunches met the SNSSL targets. However, the analysis noted that when comparing lunch types with the SNSSL, the only significant differences between groups existed for energy and vitamin C intake. A high proportion of all lunch groups failed to meet the standards for NSP, vitamin A, folate, iron, calcium and zinc.

The secondary analysis of the *Survey of Sugar intake* also highlighted the unhealthy nature of street lunches (in terms of their energy and nutrient content) when compared to other lunch options. Street lunches contained more non-diet fizzy drinks (increasing their NMES content), and more processed meat products. Their macronutrient content (energy, fat, saturated fatty acids and NMES) was higher than for the other lunch options, and their micronutrient content (vitamin A, folate, calcium, iron and zinc) was lower.

The finding that there is little significant difference in nutrition between canteen and packed lunches might suggest little reason for further investment into school meals. However, the poor nutrition provided by street lunches raises concerns, suggesting that alternatives need to be found for this lunch option, as well as highlighting the need for further research on nutrient intake provided by different lunch types – the subject of this PhD.

1.11) A review of studies examining the total daily nutrient intakes of children consuming canteen, packed and street lunches

Few studies have compared the overall diets of children taking different lunch types. A study of Scottish schoolchildren in the 1960's and 1970's (Durnin et al. 1974) found that eating school meals rather than an alternative lunch option did not affect children's energy or nutrient intakes. A study of primary and secondary school children in Kent found that, regardless of the lunch option (canteen or packed) they chose, children's nutrient intake outside school lunch time was found not to differ greatly – the differences lay in the school meal choices (Cook et al. 1975). However, it must be noted that both of these studies were conducted more than 30 years before the present study, and the foods available to children, their lifestyles, and food preferences, are likely to have changed significantly.

A study by Nelson and Paul (1983) found that energy intakes were higher on packed lunch days than days when home lunches, or canteen lunches (the lunch type with the lowest energy intake) were eaten. However, it is unclear whether this is a reflection of lunch intake, or the foods consumed during the rest of the day.

The *Diets of British Schoolchildren* report (Department of Health 1989) compared the weekly diets of children consuming canteen, packed, home, and street lunches (and also free school lunches), in terms of grams of different food types consumed, as well as daily nutrient intakes of children choosing canteen, packed and street lunches, for the age groups 10 – 11, and 14 – 15 (results for the younger group of street lunches require cautious interpretation due to very small sample size). For the secondary school children (the age group and situation investigated in the present study), the report indicated that children having the different lunch options had very similar energy and fat intakes over the whole day. The energy intakes were roughly in line with the EAR, but the fat intakes were above the DRV. However, children consuming packed lunches had notably higher daily vitamin A intakes (mean 1230ug) than children having canteen lunches (855ug) or street lunches (625ug). These figures are above the RNI for vitamin A for this age range: 600ug for 14-year-old children and 15-year-old girls, and 700ug for

15-year-old boys. The RNI for calcium is 800mg for girls of this age, and 1,000mg for boys. The mean calcium intake for boys consuming packed lunches reached the RNI, but fell short in all other lunch types and genders. The shortfall was greatest for children consuming street lunches (mean intake 870mg calcium for boys and 650mg for girls). The situation was most concerning for iron intakes. The RNI for boys of this age is 11.3mg, but higher for girls, at 14.8mg. However, for all lunch types, girls showed lower daily iron intakes than boys. The mean daily intake of boys consuming all lunch types reached the RNI, but fell significantly short in girls, most notably those consuming street lunches (mean daily intake 8.5mg), with girls eating canteen lunches having mean daily iron intakes of 9.2mg, and the highest daily intake of 9.9mg (still below the RNI) seen in girls consuming packed lunches.

A secondary analysis (Nelson et al. 2007b) of the NDNS for young people (Gregory & Lowe 2000) noted that the foods consumed at school were less conducive to health (for example higher in saturated fat and lower in micronutrients) than those eaten during the rest of the day, and the authors commented that foods consumed outside school were unlikely to be able to make up for the nutritional imbalance created by food consumed in school.

A detailed and recent study of the impact of children's school lunches on their overall nutrition was provided by the FSAS Secondary Analysis of the Survey of Sugar intake of Children in Scotland (McNeill et al. 2009a). This noted that lunches made more of a contribution to the overall nutrient intakes of primary school children than secondary school children (aged 12 – 17). Total daily fat intakes for all groups were close to the DRV, which was successfully met when canteen and street lunches were consumed, but not when packed lunches were chosen. Daily SFA intakes were higher than the DRV, with children eating packed lunches (which provided the greatest excess) consuming 181% of the DRV, and those eating street lunches (the smallest excess) consuming 133% of the DRV. NMES intakes also exceeded the DRV, at approximately 175% of the DRV, when every lunch type was consumed. Very few nutritional targets were met. Only children consuming packed lunches met the RNI for vitamin A, folate and calcium; while the RNI for iron failed to be reached in any of the groups.

It must be noted that in most cases in the FSAS study, differences in nutrient intakes between canteen, packed and street lunches, both at lunchtime and over the whole day, failed to reach statistical significance. For the secondary school children, no significant difference existed between the lunchtime intakes of children consuming canteen, packed and street lunches, with the exception of that of NMES (for which children consuming street lunches had the highest intakes, and those consuming canteen lunches had the lowest intakes).

Despite the notable differences between the lunchtime NMES intakes of children consuming canteen, packed and street lunches, these were greatly evened out when viewed over the whole day, and (along with the other nutrients examined) failed to reach statistical significance.

Millions of pounds have been spent on improving the nutritional quality of school meals, but is this justified? If children consuming street lunches consume diets that are not significantly different overall from those of children choosing canteen or street lunches, concern over street lunches might not be justified, and public health money might be better spent elsewhere.

This literature review indicates a consensus that street lunches are nutritionally inferior to packed and canteen lunches, although little detailed data is available on street lunches. Also, the literature comparing the overall nutrient intakes of children consuming canteen, packed and street lunches is extremely limited, and somewhat contradictory in terms of the extent of the contribution made towards total daily intake by canteen, packed and street lunches. It is for this reason that the present study examined the impact of lunch choice on children's overall nutritional intake, as well as comparing the nutritional contents and densities of the lunchtime meals themselves.

1.12) Review of methodology used in nutritional surveys

The measurement of nutrient intake presents many challenges, especially that of free-living individuals, and in particular children – the subjects of the present study. The appropriate dietary assessment tool depends on many factors, including what is to be measured (for example food choice and eating behaviour, frequency of consumption of food groups, or detailed nutrient intakes), in whom, and the resources available.

Deciding upon the appropriate tool will always be a compromise between the obtaining the most detailed and valid data, and the resources available. More painstaking, onerous recording methods, such as weighed (rather than estimated) intake methodology, produce more precise data, enhancing validity, but have disadvantages in terms of reducing recruitment and compliance, and increasing monetary cost in terms of administering the survey.

A larger sample size is always desirable, in order to maximise the power of any statistical analysis, but this will increase the time required collecting and analysing the data, and also the human and monetary resources required.

1.12.1) Survey methods

Very large surveys on a national level tend to utilise simple survey methods, such as the Expenditure and Food Survey (Department for Environment Food and Rural Affairs 2008), which measures food and nutrient intake trends via household food expenditure, using a food inventory method.

Recall methods

Retrospective (recall) methods are commonly used for large scale studies, as they are quick and inexpensive to administer, and also do not introduce the possibility of the study influencing the participants' behaviour. However, they do not provide precise estimates of nutrient intake (Randall 1991), and all recall methods introduce the

possibility of inaccuracy through errors of memory, the extent and probability of which is influenced by participants' age, socioeconomic status, state of health, as well as their interest in dietary matters (Krall, Dwyer, & Coleman 1988).

Food frequency questionnaires

Self-administered food frequency questionnaires (FFQ) are a technique used for population level surveys, whereby participants respond to questions on their frequency of intake for a list of foods. Nutrient intake can then be estimated based on the frequency of a food's consumption and a standard portion or estimated portion size (Bingham 1987).

FFQs have the advantage of being relatively quick and simple to analyse. However, data obtained in this way is limited regarding quantification of different foods eaten, and therefore accuracy in estimating nutrient intake is compromised (Schaefer et al. 2000). Also, uncertainty will always remain whether every participant completely understood the questionnaire.

Foods eaten frequently or to a pattern, along with those eaten only very rarely, are easier to recall than those eaten with intermediate frequency, for example a few times a week or month. This means that the memorable foods tend to be the same for a given population, and certain nutrients will be accurately estimated, but not others (Krall, Dwyer, & Coleman 1988).

Accuracy of reporting can be enhanced by combining administration of the FFQ with an interview, thus ensuring that the subject understands the questions, and allowing the opportunity to prompt for inclusion of foods in a category of the questionnaire which may be frequently forgotten.

Methodology also affects mis-reporting. In contrast to other methods, FFQs tend to produce over-estimation (McPherson et al. 2000c).

24-hour recall

The 24-hour recall involves asking a subject to describe as accurately as possible their food intake over the previous day, and is useful for estimating the mean intake of a sample (Thompson & Byers 1994). However, the 24-hour timescale provides only a snapshot of the diet which may not be typical of long-term intake. For this reason, multiple 24-hour recalls, conducted over a longer time period, are generally used to produce a more accurate portrayal of a participant's eating habits and nutrient intake (Bingham 1987; McPherson et al. 2000c).

A disadvantage of 24-hour recall is the requirement for highly skilled interviewers, the need for standardisation between interviewers, and the need for time and a location for interviews to be conducted.

Medium-scale studies can utilise either food recorded from memory (as in 24-hour recall, or diet history), or recorded at the time of consumption or soon after (as in diet records). Both methods have advantages and disadvantages.

Diet history

A diet history focuses on a subject's typical intake over a period of time, with information obtained via an extensive interview (or, more rarely, questionnaire) thus avoiding the 'snapshot' problems encountered in 24-hour recall (Thompson & Byers 1994). However, the detailed nature of the interview needed to glean this level of detail introduces the possibility of the interviewer 'leading' the subject to recall foods expected or desired in the participant's diet, even with a highly skilled interviewer. In addition, the personal nature of the interviews makes standardisation of the analysis impossible. As for 24-hour recall, time and a suitable location is required for the interviews to be carried out.

Food records/diaries

Food records (food diaries), whereby the nature and quantity of food is recorded by the participant or a researcher, parent or carer, minimise errors of memory (provided intake is recorded at the time of or immediately after consumption). Portion size may be

obtained by weighing the food before consumption, then subtracting the weight of any leftovers (weighed intake), or estimated by the recorder (estimated intake). Aids to estimation include photographs of standardised portion sizes, and verbal or written descriptions of portions.

Because of within-person dietary variability, the smaller the number of days recorded, the greater the risk that the diet recorded is atypical of that consumed over the long term. In addition, shorter recording periods can lead to overestimation of dietary quality (Eppright et al. 1952b). However, due to the onerous nature of recording, and its effect on accuracy and compliance, such studies are usually limited to periods of three to seven days (Eppright et al. 1952a; Biro et al. 2002).

Smart cards

Where meals are purchased using 'smart cards', the food choices of large numbers of subjects can be recorded and tracked, because the computer system will retain data on their transactions. A study in a large boys' school (Lambert et al. 2005c) generated precise data on the food choices made by hundreds of children, and was capable of doing so over an indefinite time period. This enabled nutrient analysis of the foods consumed, subject to the usual limitations of estimation of portion size, wastage etc.

1.12.2) *Validation studies*

The validity of a methodology can be tested by comparing its results with those from a more objective method that can be standardised. However, caution is required when interpreting dietary data even when validation studies are used, since validation studies are beset with shortcomings, often due to small study sizes, and especially where children are concerned (McPherson et al. 2000c).

Also, although validation studies are desirable to test a new methodology, they are time consuming and expensive, and therefore not always practical when designing a study (Thompson & Byers 1994).

Observation

The accuracy of dietary records may be validated by comparison with observation (by parents/guardians, staff at a canteen, or trained observers) of the food actually eaten. This method is often used for young children (Lytle et al. 1993).

Doubly labelled water

Because subjects in energy balance should expend an equal amount of energy to that consumed, techniques that accurately estimate an individual's energy expenditure (such as the doubly labelled water, or DLW technique), then compare it with the energy intake recorded by a study participant, can be used to test the validity of the study methodology (Schoeller 1988). Although doubly labelled water can only test for accuracy regarding energy intake, it can be assumed that if a dietary recording methodology is accurate for energy intake, there is a 'reasonable probability that it will also be accurate for specific nutrients' (Schoeller 1990).

Validation using doubly labeled water revolutionized the study of energy expenditure of humans under free-living conditions. The technique is noninvasive, the subjects being required to drink a liquid containing labeled oxygen and deuterium, the levels of which are measured in the urine (Bandini et al. 1997). However, it is prohibitively expensive for routine use, and the requirement for 24-hour urine samples can deter compliance.

Under conditions of weight change, energy intake and energy expenditure are not equal (positive or negative energy balance). Although growing children are in a state of positive energy balance, the extent of this is small, approximately 1 – 2% (Bandini et al. 1997), suggesting that doubly labelled water can be used for methodology validation in studies of children.

Urinary nitrogen excretion

Urine samples can be used to test the validity of individuals' protein intake, by comparing their reported nitrogen intake (protein being a nitrogen-containing compound) with urine nitrogen levels over 24 hours (Black et al. 1997). However, the compliance problems associated with repeated urine samples remain. Also, this

methodology assumes subjects are in nitrogen balance, which is unlikely to be the case in growing children (Biro et al. 2002).

However, urinary nitrogen excretion, and also doubly labelled water, is rarely utilised for validation in the school studies due to the fact that urine collection is not practical with a study population comprising a large group of children in a school setting.

EI / BMR ratio

Due to the human resources required for validation using observation, and the prohibitive cost of DLW, the accuracy of reported energy intake (EI) compared against total (actual) energy intake (TEE) is often evaluated by comparison with presumed energy requirements, expressed as Physical Activity Level or PAL, which is in turn a multiple of basal metabolic rate (BMR).

$$\text{TEE} / \text{BMR} = \text{PAL}$$

If BMR is known or can be estimated from height and body weight, this can be used to test the validity of reported energy intake.

In 1991, Black and Goldberg published seminal papers on this validation technique, (Black et al. 1991; Goldberg et al. 1991), with PAL values based on the FAO/WHO/UNU expert committee on energy requirements' figures for the energy requirements of individuals (FAO/WHO/UNU 1985).

However, a review of 574 DLW measurements of TEE (Black et al. 1996) found that the benchmark PAL values originally suggested were a conservative estimate. It can no longer be assumed that the original PAL values used to screen for validity are appropriate in all research situations (Black et al. 1996).

1.12.3) Sources of error in dietary methodology

All dietary methodology is vulnerable to both random and systematic error, the most problematic being systematic error – the tendency to underestimate or overestimate a true value. This reduces validity, the ability to measure what a study purports to measure. Systematic error is generally minimised by increasing the number of measurements taken, or the subsequent statistical treatment of the data (Black et al. 1996).

Sampling bias

If the sample used for the study is not randomly determined, the data will not be representative of the population as a whole. Respondent bias will affect many studies of dietary intake – if subjects are allowed to opt in or out, a self-selection effect will be observed, with participants tending to be those most interested in nutritional matters.

In order to minimise respondent bias in the present study, every pupil in the school years selected was given the opportunity to participate, and the study was introduced to the pupils and set up during home economics lessons, and incorporated into the subject areas they were covering. The food diaries were made as child-friendly as possible, and data collection period limited to what was considered a reasonable for the age group, in order not to deter less interested individuals.

Recording error

People may not record what they actually eat. These inaccuracies may be intentional, for example lack of honesty in recording foods perceived as unhealthy (Young & Trulson 1960). Alternatively they may be unintentional, for reasons including the following: errors in weighing food, in writing down weighed or estimated food, forgetting to record food at the time of consumption and either omitting it or relying on memory, or the inability to accurately estimate portion sizes.

An extremely important and problematic source of error in dietary studies is that caused by over- and under-reporting. There is a general tendency for individuals to report not

what they actually eat, but their 'perceived norm' for the population with which they identify (Schoeller 1990).

Under-reporting is the more frequent of these forms of mis-reporting, and may be seen across all food groups, though energy-dense and carbohydrate dense foods are most likely to be under-reported (Heitmann & Lissner 1995; Krebs-Smith et al. 2000), meaning that intake data calculated for nutrients such as sugar, fat, and fat-soluble vitamins are likely to be under-estimates also.

Certain sectors of the population are more likely to under-report, and serious underestimation of intake can be seen in the obese (Lichtman et al. 1992). However, people of normal weight also under-report (Lichtman et al. 1992). The phenomenon of under-reporting is also a significant problem in dietary studies of children and adolescents, see below (section 3.4.6).

Methodology also influences the extent and likelihood of under-reporting, with diet history tending to produce more accurate data than diet records (Bingham 1987).

Detection of under-reporting

The ratio of reported energy intake to basal metabolic rate (EI / BMR) is often used to test the accuracy of food records, with a ratio below a certain value usually regarded as an implausibly low reported energy intake, in other words, too low for the maintenance of body weight. This ratio is commonly known as the Goldberg cut-off (Goldberg et al. 1991).

However, if the PAL on which this cut-off is based is inappropriate, subjects will be wrongly excluded from data analysis, and deciding upon the most appropriate PAL, taking into account age, as well as gender, is a contentious issue (Goldberg et al. 1991).

Also limiting the usefulness of the technique is the fact that subjects who under-report because they altered their diet to make recording more convenient, are not detected by using ratio of EI / BMR to detect under-reporters (Macdiarmid & Blundell 1997). This

means that under-reporters may be just as much a problem among respondents with plausible EI / BMR.

Regardless of advantages or disadvantages, it was not possible to use EI / BMR in the present study, as the schools did not give permission to measure the children's weights or heights.

Effect of methodology on behaviour and recording

Although prospective study methods minimise errors of memory, the methodology, and even the knowledge that they are participating in a study, may influence subjects' behaviour, so that the food eaten is not a true reflection of their habitual intake. For example, subjects may eat less, or simplify their eating patterns, to make the recording process more straightforward. Weighed intake studies in particular have been found to interfere with normal eating behaviour (Macdiarmid & Blundell 1997).

In addition, subjects may also avoid eating foods perceived as 'unhealthy' (Macdiarmid & Blundell 1997), or not record them when they do (though this problem also exists in retrospective methods). To minimise this effect, studies often assure subjects' anonymity – this was the case in the present study.

Food tables

There are several sources of error inherent in the use of food composition tables, or computer software based on them. Most studies utilise the Royal Society of Chemistry's food tables contained in McCance and Widdowson's *The Composition of Foods* (Food Standards Agency 2002b), which acknowledges that although the values it contains are derived from careful analysis of representative samples of each food, all foods vary in composition, based on a variety of factors. The nutrient content of unprocessed plant or animal based foods depends on their variety and the conditions in which they were grown or raised. The storage of food will also affect its nutrient content (Food Standards Agency 2002b).

Nutrient composition of manufactured food products varies widely between brands. The increasing addition of nutrients for fortification, colouring or antioxidant purposes also

means that figures in food tables may not be a true representation of foods eaten by the sample population. Loss of validity due to variation in manufactured products can be minimised by using nutrient data supplied by individual manufacturers, but this is time consuming and also depends on study participants reliably recording brand details, and is therefore generally impractical for most studies, especially those involving children.

Additional error may be introduced in transforming food intake data into data on nutrient intake, for example as a result of errors in interpreting entries in food diaries, or coding and entering foods for analysis using dietary software.

Finally, participants may list incomplete information in food diaries, for example listing 'milk' but not whether it was skimmed, semi-skimmed or full fat. In these cases, the researcher will generally base their analysis on the option most frequently consumed, but the possibility for loss of validity remains.

Table 7: Major error sources in recording of food consumption (adapted from (Bingham 1987)

Sources of error	Weighed record	Estimated record	24-hour recall	Diet history / FFQ
Weights of food	-	+	+	+
Frequency of consumption	-	-	-	+
Respondent bias	+/-	+/-	+/-	+/-
Interviewer bias	-	-	+ / -	+ / -
Daily variation in intake	+	+	+	-
Reporting error (additions/omissions)	+ / -	+ / -	+ / -	+ / -
Change in diet	+ / -	+ / -	-	-
Sampling bias	+	+	+	+
Food tables	+	+	+	+
Coding errors	+	+	+	+

+ = error present - = error unlikely + / - = error possible

1.12.4.) *Determining the number of days required*

In all forms of dietary assessment, the number of days required to compare the average intake of groups, estimate usual intake, or rank individuals, depends on the nutrient or nutrients under consideration, and also the subjects' age group, gender, and the variability characteristically seen in their diets. Nutrients requiring the most days to accurately assess their intake tend to be those found in high levels in infrequently eaten foods, and also showing high intra-individual variability; these include retinol, carotene and vitamin B12 (Nelson et al. 1989). Another study (Eppright et al. 1952b) found high variability in vitamin C intake. The nutrients with the lowest within- to between-subject variances (therefore requiring the least days to adequately estimate their intake) were energy, protein, SFA and calcium (Nelson et al. 1989).

1.12.5.) *Measuring dietary intake in children and teenagers – special considerations*

Due to the differences between children and adults' eating patterns, and food choices, measuring dietary intake in children and adolescents poses unique challenges. In children, limited cognitive abilities, memory and attention span make dietary recall, recording, and estimation of portion sizes, difficult (Nelson et al. 1989). Children are also less able to recall, estimate, comprehend and co-operate in dietary surveys than adults, necessitating the use of surrogate reporters in young children (Thompson & Byers 1994).

The younger the child, the less food-related knowledge could be expected of them, for example regarding identification of foods; this could reduce the validity of nutrient intake data. Also, children are less likely than adults to have been involved in food preparation, so they may not know, for example, the cooking methods used, or whether milk used was skimmed, semi-skimmed or full fat.

Compliance

Because of the novelty and appeal of dietary recording and interviews, compliance in primary school age (7 – 10 years) children is generally good, particularly with help and encouragement from adults including parents and teachers. However, in older children and teenagers, more responsibility for recording falls to the subjects themselves, at an age when motivation for such activities is low, and the desire to assert independence is high (Robinson et al. 1999).

With time, 'recording fatigue' can be expected to set in, whether children are completing food records themselves or with adult assistance. Persson and Carlgren (1984) note that most parents and children could only accurately record five to six days of food intake, and this figure could be expected to be lower for less motivated teenagers.

Recall

Retrospective dietary methodology (FFQ, 24-hour recall, food history) introduces considerable error due to children's ability to accurately recall food and portion sizes eaten (Baranowski & Domel 1994). Also, in 24-hour recall, children's recall of single meals is better than that for whole days (McPherson et al. 2000c).

However, although this would suggest that diet records were more accurate than recall methods for children, validation studies comparing different methodologies have provided conflicting results, and estimated intake diet histories have been found to produce results more representative of habitual diet than 7-day weighed intake diet records (McPherson et al. 2000b).

Estimation of portion size

Weighing food enables greater precision in regarding portion size, but younger children (for example primary school children) generally require adult help in such techniques (Ruxton, Kirk, & Belton 1996).

Weighing food consumed removes inaccuracies created by estimation, but introduces problems with compliance and resources required, so many studies utilise estimated portion sizes. Ability to estimate and accurately recall or record portion size varies between different age groups and genders, and depends on conceptualization and memory, both of which may present problems for children (Biro et al. 2002).

Training in portion size estimation can improve accuracy in adults, but little validation method on this technique exists for children, and it should not be assumed that this would be the case in this age group; it could cause confusion (Biro et al. 2002).

Variability of food / nutrient intake

Children's diets are extremely variable, with variance ratios of children and adolescents aged 5 – 17 years approximately twice that of adults (Biro et al. 2002). Because of this extreme variability of children's food choices over time (Lambert et al. 2005a), longer study periods produce greater validity than shorter studies. The proportion of children in a group recording a 'good' or 'bad' diet on any one day may be very different to that

obtained after three, five or more days (Eppright et al. 1952b), with more days' records producing more representative results. In addition, the intake of some foods, notably fruit and vegetables, show greater day to day variation in children's diets than foods such as meat, cereals and milk (Eppright et al. 1952b).

Young children (aged 1 – 4) require fewest days, and girls aged 5 – 17 require the most, due to dietary variability. Regardless of age, girls always require more days to accurately assess their intake than boys (Eppright et al. 1952b; Nelson et al. 1989), except in the case of total sugars intake (Nelson et al. 1989).

However, despite their advantages regarding validity, long studies are onerous for the participants and, especially with children of the age group in the present study, compliance would have been harder to achieve with a longer study, and could have been expected to lead to unacceptable drop-out rates. Nelson et al (1989) note the need for the maximising the number of days' record for older childrens (because of their highly variable eating behaviour), but accepts the difficulties involved in working with this often poorly motivated age group.

(Because of the tendency to show more within- to between-subject variance in their nutrient intake, in studies including both sexes, males will be ranked more accurately for most nutrients than girls (Nelson et al. 1989).)

Under-reporting

As with adults, under-reporting is a significant problem in dietary studies of children, and is influenced by age, weight and gender. Children's tendency to show under-reporting increases with age (Nelson et al. 1989; Champagne et al. 1998). In contrast, diet histories have appeared to avoid this age-related trend towards increasing under-reporting (Champagne et al. 1998), though the diet history data lacked precision at the individual level.

Although children and adolescents of normal weights under-estimate, this tendency is greater in obese individuals (Bandini et al. 1990; Domel Baxter et al. 2006). Under-estimation is also more prevalent for energy-dense foods (Krebs-Smith et al. 2000).

1.12.6.) *Selecting the most suitable dietary recording methods for children and teenagers*

Because of the special considerations required for dietary methodology for studies of children, selecting the 'best' methodology is even more fraught with contention than studies of adults.

A review on the measurement of dietary intake in children (Krebs-Smith et al. 2000) states that "No universal criteria can be applied to select data collection methods suitable for studies of children and adolescents".

Recalls and reports versus FFQ

A review by McPherson et al (McPherson et al. 2000c) on the validity and reliability of dietary assessment methods for children concludes that methodology based on recalls or reports show greater validity than food frequency questionnaires. Another study (McPherson et al. 2000a) states that diet records and 24-recalls (and to a lesser extent, diet histories) provide the most valid group estimates of energy intake for young children.

Diet history

As already noted, diet history, in contrast with other survey methodology, has a tendency to produce over-reporting. In addition, diet history, when compared with FFQ in children aged 5 - 13 interviewed with a parent present, was found to produce greater over-estimation (Rasanen 1979).

However, although diet history tends to over-estimate energy intake in children up to nine years old, it is accurate in 15 – 18-year olds (Rasanen 1979).

It might appear therefore that diet history is the methodology of choice for dietary surveys of teenagers, certainly at the group level, but this conclusion would be based on a small number of studies, and Livingstone (Rasanen 1979) precludes any firm conclusions on superiority of any methods.

In addition, the memory-related limitations of all recall methods remain, and food records would be expected to produce data of greater precision. Since records are made at or near the time of eating, it is easier for subjects to record precise food details such as portion sizes and brands.

Diet records

Published research suggests that children over the age of nine or ten can satisfactorily record their own diets (Domel et al. 1994; Frank 1994). In this age group, 3-day diet records have been found superior to FFQ and 24-hour recall in 9 – 10-year-old girls (Crawford et al. 1994). Regarding older children, 3-day diet records were found superior to 24-hour recall in 14-year-old children (Mullenbach et al. 1992b).

Good validity has been found (Mullenbach et al. 1992a) for weighed diet records in 7- and 9-year-old children. However, the data from adolescents aged 12, 15 and 18 showed large increases in under-estimation with age. Bandini et al (1997) also noted this large and increasing under-reporting with age, but suggests that although diet record may not accurately reflect dietary intake at the individual level, this technique is useful to assess patterns of food consumption despite its limitations.

Weighed versus estimated intake

Although methodology does appear to influence the extent of under-reporting, it appears that the magnitude of under-reporting is independent of the use of weighed intake versus estimated measures (Bandini et al. 1997), with both exhibiting under-reporting to some extent.

In a study involving adult participants, Edington et al (1989) suggest that estimated intake is not substantially less reliable than weighed intake. Good agreement between weighed and estimated intake data has also been found in children (Hackett et al. 1983).

In view of several practical constraints, the researcher decided against weighed intake for the present study. The children were at an age expected to be particularly self-

conscious, when weighing every item of food would have caused sufficient embarrassment for them to abandon the study or estimate rather than weighing their food. Carrying weighing scales around school, to after school activities, and particularly to out-of-school food outlets during lunchtime, would have been particularly onerous and off-putting for the participants. The number of scales available was a further limitation; budget constraints govern the number available, and having only a small number of scales available would necessitate children to participate in the study in successive groups, prolonging data collection over several months. There was concern about how easy it would be to recovering scales from participants after they had completed their phase of the study.

Deciding on the appropriate number of days' study

When studying an individual's habitual intake, more days are required in order to enhance the precision of any estimate of intake of a particular nutrient. However, when studying a population, increasing the size of the sample is a better way of enhancing statistical relevance (Nelson et al. 1989). For this reason, and because it was not possible to obtain anthropometric data and therefore calculate BMI and PAL, the present study endeavoured to obtain as large a sample as possible.

In theory and in general, provided a large enough sample size is obtained, diet records produce the best estimate of usual current intake, with 7 days of records producing the optimum compromise between precision, participant compliance and resources required (Nelson et al. 1989).

An adult study by Edington et al (1989) found no significant difference between 4-day and 7-day estimated weight food records, concluding that it is acceptable to decrease days of recording (at least by this extent) in order to maximise compliance. Another adult study (Karvetti & Knuts 1992) found 2-day estimated intake food records to provide 'satisfactory' validity at group level, and 'probably acceptable' for individuals. A study of graduate students (Todd, Hudes, & Calloway 1983) found 1-day food records (weighed and estimated) to give a reasonable estimate (within 15%) of usual intake for groups, but a meaningless estimate of usual intake for individuals.

Reliability

A study of 9 – 11-year-old children in the USA (Eppright et al. 1952b) found the only seasonal differences for the group in vitamin C and energy intake, which were higher in spring than autumn; while a Swedish study on 4 – 13-year-olds (Persson & Carlgren 1984) also found a seasonal difference for vitamin C, though this was higher in winter (due to consumption of citrus fruits), suggesting that seasonal variations may vary depending on the setting. A study of 11 – 13-year-old children in England (Hackett et al. 1985) found no seasonal variations in energy, protein and total sugars intake, and noted that although seasonal variations in the intake of different foods could be strong, the seasonal effect on nutrient intake appeared to be small and unlikely to complicate many surveys. This study also noted the unpredictable and inconsistent effect of the day of the week and concluded that for this reason all days should be sampled in dietary studies. A study of 11 – 12-year-old Australian children (Jenner et al. 1989) found day of the week to have only a small effect, while a study of American university students (Todd et al. 1983) found no effect.

Considering the special behaviour of teenagers

Although there is obviously great variability in individual children's ability to comprehend and carry out the instructions for dietary surveys, there is a general consensus that different methodologies are suitable for different age groups. 24-hour recalls provide reasonable accuracy with children over the age of 10 years (or younger if a parent or guardian's help is enlisted) (Biro et al. 2002), while to comprehend a food frequency questionnaire children should be over 12 years old (Robinson et al. 1999).

Teenagers are more capable regarding recall and recording ability, but compliance is more of a problem, with the novelty of recording food intake less appealing than for younger children. Compliance is a particular problem in this age group, and there can be a notable decline in interest as studies utilising diet records progress (McNeill et al. 1991).

In the teenage years, eating habits become more unstructured, with less adult supervision and more control over foods eaten, more food eaten outside the home, and fewer formal 'meals'. In addition, eating behaviour becomes a means of self-expression

as youngsters use their food choices to 'rebel' (McNeill et al. 1991). These factors must all be considered when interpreting results, using any methodology, from studies of teenage diets.

1.13 Aims and objectives of the present study

Background and justification for the study:

School children have three main options available to them at lunchtime:

- Canteen lunches: those purchased in the school dining hall
- Packed lunches: those brought from home
- Street lunches: those purchased by the children outside school

Large amounts of funding have been invested into improving the standards of canteen lunches, (see literature review) but is this money well spent?

Are canteen lunches nutritionally superior to packed and street lunches?

Do children who eat nutritionally poor lunches compensate for this with food consumed during the rest of the day? If this is the case, it might be implied that funding might be better targeted towards initiatives focusing on children's diet outside school time.

Overall aim:

To determine the nutrient content of different types of lunchtime meal, and their contribution towards the overall daily nutrient intakes of 11 - 14-year-old schoolchildren from two secondary schools in Scotland.

Objectives:

Section a – lunch analysis

- 1 To establish intake of ten of the nutrients included in the Scottish Nutrient Standards for School Lunches, (SNSSL) (Scottish Executive 2003b), as well as the nutrient density, for three lunchtime options (canteen, packed and street lunches), for a sample of 11 – 14-year-old children attending two secondary schools in Fife, Scotland.

Section b – whole day analysis

- 2 To estimate nutrient intake of ten of the nutrients included in the Scottish Nutrient Standards for School Lunches (SNSSL), achieved in days containing three different lunchtime options, for the sample described above.

Section c – relation of lunchtime and whole day intake

- 3 Determining contribution of the canteen, packed and street lunches to overall intake.
- 4 To assess whether lunches which were nutritionally poor at lunchtime, were compensated for with food consumed during the rest of the day, in order to achieve a diet that was adequate overall.
- 5 Determining whether this differed for days including canteen, packed and street lunches.

Chapter 2 – Methodology

2.1) Reasons for choice of methodology in the present study

Five-day estimated intake diet records were selected as the methodology for the present study. The review by McPherson et al (2000c) of dietary assessment methods for school-aged children concludes that although diet records are not useful for individual health outcomes, they are a good technique for the study of group intake, which is the aim of this PhD.

In spite of some apparent validity advantages of diet history for studying the food intake of young teenagers of the age relevant to the present study (Livingstone & Robson 2000), its relative lack of precision, and the limitations of all recall methods, a food record was decided upon as the appropriate methodology for the present study. A further reason for this decision was the fact that the study schools had no rooms available for conducting interviews with the children.

A written diet record (food diary) requires a child to write legibly, recognise and conceptualise portion sizes and record them in whole units or fractions, decipher food labels, as well as not losing their diary during the study. It was judged, based on reviewing the literature, the experience and results of the pilot study (see section 1.9., 2.2.8) and consultation with the school teachers concerned, that children of the age considered in the current study would be capable of this.

It was decided not to use an interview method such as 24-hour recall or diet history for the present study due to the practical limitations of working with the schools participating in the study. Removing children individually from classes was judged by the schools to be too disruptive, and requiring them to give up time during their breaks was anticipated to seem too much of a sacrifice for the participants, which would have severely limited compliance. In addition, meeting rooms were not available for meetings with pupils.

Estimated intakes were used rather than weighed intake, for the following reasons. In order to achieve the desired large sample size, either an impractically expensive number of weighing scales would have been required, or smaller groups of children (corresponding to the number of scales available) would have had to complete data recording consecutively. This second option would have prolonged the data collecting phase of the study to an extent judged to compromise validity to an unacceptable extent. In addition, the act of weighing the food in a busy canteen environment would not have been possible, as it would slow down the lunch process to an extent unacceptable to the children and the school. Also, many of the foods consumed by the children, such as soup, would have been impractical to weigh. Finally, children purchasing street lunches would not have been able to weigh their purchases in the street before consuming them.

A validation study was not conducted due to the following practical constraints. Because the schools would not allow measurement of children's heights and weights, calculation of PAL was not possible. Doubly labelled water and urinary nitrogen excretion were not used due to the expense of these techniques and, on a practical level, the fact that permission was not granted by the school to collect urine samples from the children. The school would not allow urine to be collected for reasons of health and safety regulations, and it was also anticipated that parental consent and compliance by the children would have been too difficult to obtain.

For the present study (which was of a population, rather than individuals), children were asked to record their diet for five days, in order to maximise the representativeness and validity of the data. Also, this length of sampling made the present study comparable with the requirements of the Scottish Nutrient Standards for School Lunches (Scottish Executive 2003b), which are for nutrient intake averaged over five days.

However, in view of the studies above, and the fact that data was analysed 'per day' (with each lunch providing a record) rather than 'per child' (with each record comprising several days' data from a single child), data from children completing fewer than five days of records was accepted.

Since teenagers' diets are known to be extremely variable, the present study made particular efforts to maximise the sample size; more subjects are required to estimate average dietary intake if diet is variable than if the diet is homogenous (Thompson & Byers 1994).

To maximise the reliability (the ability of methodology to produce the same estimation on different occasions assuming that nothing has changed in the interim) of the present study, the influence of the season, and day of the week, were considered.

The present study was only concerned with school day nutrient intake, so did not collect data for weekends, thus avoiding any potential effect of different food consumption patterns at weekends. A proportion of children in the study started the study on each week day (depending on the day of their introductory home economics lesson).

Data was collected during the autumn (September to December) and spring (January to March) terms. Also, by the completion of the second phase of data collection (spring term 2008), data from over 1,532 meals had been collected. This was judged to be a very large sample for a study of this kind and, upon statistical advice from Queen Margaret University, sufficiently large for the statistical analysis required for the present study. In addition, the researcher had committed to the schools involved to analyse every food diary completed by the children (to respect the children's efforts in completing them) and it was anticipated that undertaking a further wave of data collection would produce too many diaries for the researcher to analyse with the resources available. Although the first phase of data collection included fewer children than the second, this would not have skewed the data regarding the effect of the season.

Secondary school children were chosen for this study, due to the paucity of detailed data on this age group. Rather than trying to produce a sample that was representative in socioeconomic terms of Scotland as a whole (an undertaking which would have necessitated a sample size beyond the resources of this study) it was decided to sample from a minimum of two schools attended by pupils from families with similar socioeconomic profiles.

2.2) Description of methodology used in present study

After gaining ethical approval for the research from Queen Margaret University, three High schools in Dunfermline were earmarked for the study, and approached by the author and Queen Margaret University by letter.

One school declined to take part but two – Queen Anne High School and St Columba's Roman Catholic High School - agreed to allow pupils to participate. Both schools are for pupils aged 11 – 18 years. Queen Anne has a population of approximately 1,800 students, and St Columba's 920.

Queen Anne High School has an Acorn Classification of Type 3, 'Villages with wealthy commuters', while St Columba's is classified as Type 2, 'Affluent working families with mortgages'. The Acorn classification of demographic information for the UK (CACI 2009) in this instance provides a somewhat misleading impression, since an Acorn classification relates to a postcode area of approximately 15 properties, so only provides a snapshot of the few houses in the immediate locality of each school, rather than the entire catchment area. Both schools had similar catchment areas which included local authority housing, shared ownership, as well as private ownership.

To provide an alternative indication of socioeconomic profile, the percentage of pupils entitled (and registered) for free school meals at the two schools were compared with the percentage for Scotland as a whole. Scotland-wide, 13.4% of secondary school pupils were entitled to free school meals in 2008, the year in which the present study was conducted (12.7% of pupils were actually registered for free school meals) (Scottish Government 2008a). In comparison, 8.2% of pupils attending Queen Anne High School were entitled to free school meals (7.7% of pupils on the school roll were actually registered for free school meals). At St Columba's, 17.7% of pupils were entitled to free school meals (16.5% of pupils on the school roll were actually registered for free school meals) (Scottish Government 2008d). Therefore, St Columba's High School had a percentage entitlement for free school meals 4.3% higher than the

national average, and Queen Anne High School had a percentage entitlement 5.2% lower than the national average.

Initial meetings were held with the rectors (head teachers) of the two schools and with the heads of the Home Economics departments to discuss the purpose, methodology and execution of the study. Although both schools were enthusiastic about participating in the study, they refused to allow children to be weighed or measured for anthropometric data, or for urine or blood to be collected. However, since this study was primarily concerned with nutrient intake, this was not judged to be a problem. It was decided to concentrate on collecting food intake data, and to obtain as large a sample size as possible in order to maximise the power of the analysis.

2.2.1) Recruitment of sample

Initially parents/guardians of all second year (S2, aged 12 - 13) pupils at both schools were approached via two letters (one from Queen Margaret University, accompanied by a letter from the school, see appendices), plus a tear-off form to fill in and return if they did not want their children to participate in the study. This amounted to 325 pupils at Queen Anne High School and 170 at St Columba's. Parents were also given an information sheet on the study, and pupils were given their own information sheets (using child-friendly terminology) to help them to feel included in the study process (see appendices).

In the event of insufficient participants completing the diet diaries satisfactorily, it was planned that first and/or third years would be invited to participate during the second term of the school year. It was decided to leave the possible inclusion of first year pupils until the second sampling period on the advice of the school staff, who had observed that during their first term at secondary school the novelty of having a variety of lunch choices available, and also being allowed to leave the school premises at lunch time, resulted in pupils 'flitting' more from one option to another for the first term before settling to a more regular pattern of lunchtime eating in future terms.

To provide an added incentive for pupils to complete their food diaries, 13 x £5 WHSmith vouchers were provided to Queen Anne High School, and 7 to St Columba's, for prize draws into which every student satisfactorily completing a diary would be entered. The nature of the prizes were decided upon after consultation with the school's teachers, who had consulted the pupils, who reported that they were a 'good prize' which could be spent on a variety of popular products, most notably music downloads and magazines.

Due to an insufficient sample size (132) being obtained from S2 pupils, during the first round of recruitment (in September and October 2007), in the following term all third year (S3, aged 13 - 14) pupils at Queen Anne High School and all first year (S1, aged 11 - 12) pupils at St Columba's High School were approached for the study. These years were selected on the advice of the school home economics departments, to fit in with the areas being covered by the curriculum at the time of sampling.

This amounted to distributing letters, food diaries and information packs to a further 329 pupils at Queen Anne High School and 174 at St Columba's. The second round of data collection took place during January 2008. Food diaries were given to 953 children in total.

2.2.2.) Classification of food consumed, and food availability

To help inform the analysis of the food intake data, prior to distribution of the diaries the availability and nature of the food available to the children during school time – both in school and in the local area - was investigated. (It was accepted that investigation of foods consumed out of school hours would not be feasible).

Several children omitted to record whether milk consumed was skimmed, semi-skimmed or full fat, although they were asked to do so. If their diaries were otherwise acceptable, it was assumed that milk was semi-skimmed, as this is the milk most commonly consumed by children in the UK (Gregory & Lowe 2000). All milk sold in the schools was semi-skimmed.

Where children did not specify the size of packets of crisps consumed, these were assumed to be 27g (the size sold in most multi-packs) if crisps were eaten at home or in a packed lunch, or standard size 37g if they were purchased from a shop outside school or from the school canteen.

A portion of fruit was defined as approximately 80g, equating to, for example, a medium-sized fruit such as an apple, pear or orange, or two small fruits such as satsumas. If pure fruit juice was consumed, one serving (a 200ml carton or serving), but no more, was counted as a portion of fruit, regardless of how much more juice that child drank that day. If fruit juice was consumed during lunchtime and at another time, it was the lunch serving that was included in the statistical analysis for the present study.

Canteen food

Canteen menus were set by Fife Council, and were required to abide by the *Scottish Nutrient Standards for School Lunches* (SNSSL) guidelines in place at the time of the study (Scottish Executive 2003b). Both schools served a small selection of hot dishes. Boiled potatoes and vegetables were provided as accompaniments, with chips served a maximum of twice weekly. Soup was available, and consumed by some pupils.

Sandwiches, filled baguettes, rolls and wraps were available. The filled baguettes were large, comparable in size to those purchased outside school. Some of the filled bread options included salad. Reduced-fat spread was used in filled-bread options. Where mayonnaise or dressing was included, this was reduced fat.

Dessert options included low-fat yogurts (including 'crunch corner' varieties), and fruit salad boxes.

Snacks included low-fat crisps and savoury snacks, two-finger Kitkat chocolate wafer biscuits, 'giant cookies', small bags of mini cookies, and cereal bars.

Drinks on sale included fruit smoothies, low-fat flavoured milk, pure fruit juice, low-sugar energy drink (Lucozade), low-calorie blackcurrant squash (Ribena), bottled water and flavoured water.

Vending machines

St Columba's High School had a vending machine in the canteen, stocked only with foods and drinks permitted by the SNSSL. Food and drinks purchased from these were classed as 'Canteen lunch', as they were purchased on school premises, and the foods were limited to those allowed by the Scottish Nutrient Standards for School Meals (Scottish Executive 2003b).

Tuck shop

St Columba's High School had a tuck shop serving food during the morning and lunch breaks. The food on sale was not limited by the Scottish Nutrient Standards for School Meals (Scottish Executive 2003b). The tuck shop closed during the summer term of 2009, due to the early introduction at this school of the new stricter limitations on food that could be purchased in schools (Scottish Government 2008b); it was judged that the foods that would be permitted would not be appealing enough to pupils to attract sufficient sales. For the purposes of this study, food from the tuck shop was classified as 'Street lunch' even though it was purchased on school premises, as it was not limited by the nutritional guidelines (and, most notably, sold a much wider range and larger portions of chocolate and confectionary than the limited range on sale in the canteen under the SNSSL regulations), and was sold outside the canteen environment. In addition, informal discussion with the children revealed that they saw tuck shop food as completely 'different' from that purchased from the canteen. It was also felt that classifying tuck shop food – which was often very high in fat and sugar – as part of canteen lunches, would skew the results to make canteen lunches look less conducive to health than they actually were.

Vans on school premises

Both schools had a 'Healthy van', organised by the County Council, parked in the school grounds during the morning and lunchtime break, from which children could purchase foods and drinks from a very similar menu to that offered in the dining hall (minus the hot dishes). Foods from the Healthy Van were limited to those permitted by the SNSSL.

A commercial 'Snack van' also parked on St Columba's School premises, from which children could purchase a wider range of foods and drinks, not limited by the SNSSL, during morning and lunchtime break, and including pizza slices, deep-fried chips, burgers, hot dogs, fizzy drinks, crisps and confectionary. (The year following the present study, this van was made to move off school grounds to an adjacent housing estate).

Food and drink purchased from the vans (both 'Healthy' Council vans, and commercial 'Snack vans') was classed as 'Street lunch', since this is how the children perceived it. The child had chosen to buy their own food 'outside school', rather than have a 'school lunch'. Previous research (Norris 2005) suggests that children see food purchased outside school as 'different' from canteen food.

The availability of different foods from vending machines, tuck shops and vans was limited in the year following data collection, and this is considered in the Discussion of this thesis.

Foods available outside school

In addition to food available from the canteen and from packed lunches, pupils were able to leave school during the lunch break to purchase food from various retail outlets, and these were examined by the researcher before data collection commenced.

The following options were available within easy walking distance and frequently used by pupils. At these outlets they purchase a wide range of foods, many of which were not permitted under the SNSSL.

From Queen Anne High School pupils could walk to:

Within 3 minutes of school:

- A 'Snack van' van parked in a street near the school. Here pupils purchase a range of pizza slices, chips, burgers, hot dogs, fizzy drinks, crisps and confectionary.

Within 6 minutes of school:

- A fish and chip shop
- A Chinese takeaway

Within 10 - 15 minutes of school:

The main town centre is within this distance giving pupils access to a full range of food outlets including:

- 7 baker's shops. In addition to a range of cakes, pies, sandwiches, pastries, sandwiches and filled rolls, crisps and soft drinks, meal deals were available from branches of a bakery chain – a sandwich or bridie (pasty), a cake (ring, jam or fudge doughnut) plus a can or bottle of sugar-sweetened carbonated drink).
- 2 supermarkets
- A McDonald's restaurant
- A fish and chip shop
- A Chinese takeaway
- An Indian takeaway
- Three sandwich bars
- Several coffee shops and cafes
- Several newsagents selling crisps and confectionary

From St Columba's, children could walk to:

Within 3 minutes from school:

- The Healthy van and Snack van described above, both parked on the school premises. Here children purchased from a range of pizza slices, chips, burgers,

hot dogs, fizzy drinks, crisps and confectionary. (The year following this study, this van was made to move off school grounds to an adjacent housing estate).

- A convenience store (selling crisps, confectionary, soft drinks, pot noodles, meat pies, pork pies etc).

Within 10 minutes from school:

- An Asda superstore with an in-store fast food (McDonalds) outlet.

Within 12 minutes from school:

- A baker's shop. This belonged to the bakery chain described above, and sold the same meal deals, as well as a range of bakery produce, sandwiches and filled rolls, crisps and soft drinks. As above, in addition to a range of cakes, pies, sandwiches, pastries, sandwiches and filled rolls, crisps and soft drinks, meal deals were available – a sandwich or bridie (pasty), a cake (ring, jam or fudge doughnut) and a can or bottle of sugar-sweetened carbonated drink).
- A fish and chip shop
- An Aldi supermarket
- A Tesco superstore with an in-store café selling food – including fast food options – which could be served to eat in the café or to take away (the version chosen by the participants).

2.2.3.) *Roll-out of the study within each school*

The researcher participated in school assemblies to explain the project to the children, and also attended home economics classes prior to data collection to explain the study further, and answer questions from pupils.

Diet diaries, information packs giving helpful tips and information on how to complete the food diaries (see appendices), and large sealable plastic envelopes for returning the diaries and retained food wrappers, were distributed to all participating pupils during their home economics lessons. The diaries were based on a design previously used during a smaller pilot study at a different school in the area by the researcher (see

section 1.9, 2.2.8), recording foods consumed by pupils choosing to buy their own lunch outside school, which had been found to be practical and easy for the children to complete (Norris 2005).

This diary format was adapted to cover the whole day, over five school days, and slight adaptations to wording were made after consultation with the home economics teachers in the new study. The diary design comprised a booklet folded and stapled to A5 size, to make it easy for the children to carry the diaries throughout the day.

The children were asked to complete a diary of their total daily intake for five consecutive school days (to miss out weekends, and allowing children who were absent from school owing to sickness to continue recording during the following school week). They were required to include all food and drinks consumed within the period.

The study was explained to the children by their teacher and the researcher, and detailed advice was given on the importance of recording all foods and drinks consumed each day. The children were encouraged to write up their diaries as soon as possible after eating to maximise accuracy. The importance of portion sizes was emphasised and children were asked to retain wrappers, packets and nutritional information panels from food packaging where possible in order to assist the researcher in identifying foods eaten. The children did this enthusiastically.

Participants were asked to describe non-packaged food in terms of similar sized objects, such as 'an apple the size of a tennis ball', or 'a baked potato the size of a computer mouse' rather than simply 'small' or 'large'.

Children were also asked to record where purchased food was obtained from, since portion size and food composition varied between the school canteen and the many accessible food outlets outside, and it is important to obtain the maximum information of this nature in order to obtain valid nutrient data (Frank 1994).

Participants were asked not to change their normal diets in any way during the period of diary recording, or to alter what they recorded in order to make them appear healthier.

The food diaries were anonymous, but on the first page of the diary there were spaces where the participants were asked to write their age, sex, whether they were vegetarian or had a special diet (for example for medical reasons), and whether they had free school lunches. Participants were asked to record any vitamin or other nutritional supplements taken, but only two children did so, and this information was not considered in the data analysis of this study.

Participants were also asked to record their usual lunch option - school meal, packed lunch, or street lunch (lunch purchased by the child outside school). In the event this information was not used in the present study as it was discovered that many children did not have a 'usual' option but instead chose different options on different days, and indeed sometimes mixed more than one option on a single day.

It was later decided not to consider free school meals as part of this study, as only 11 participants of the 332 indicated that they were entitled to free school meals and only nine of this number actually ate a meal provided by the school. The remaining children either had packed lunches or bought food and drink outside school (street lunch).

When pupils had completed their diaries, the diaries were placed in the plastic envelopes, along with any food wrappers and packaging, and handed in to the home economics teachers, for collection by the researcher. Home economics lessons took place twice weekly, when the pupils were reminded to complete their diaries, and those who had not handed them in were encouraged to do so.

2.2.4.) Nutritional analysis of the food diaries

After diaries had been accepted or rejected, nutritional analysis was carried out by the researcher, using WinDiets computer software (Wise 2005). WinDiets allows analysis of up to seven days' food intake, more than sufficient for the purposes of this study. The software also allows the day's food intake to be divided into six 'meals': breakfast, morning snack, lunch, afternoon snack, evening meal and evening snack.

This study required the three lunch types (canteen, packed and street) to be analysed separately. Also, analysis of the full day's food and nutritional intake would be required.

In order that as detailed as possible an analysis could be carried out, with the prospect of investigating other aspects of the children's food and nutrient intake (for example snacking) in the future, the WinDiets meal slots were re-coded for the purpose of this study, as follows:

Table 8: WinDiets meal coding for the present study

WINDIETS MEAL	STUDY MEAL RE-CODING
Breakfast	Breakfast
Morning snack	Snacks (whenever eaten)
Lunch	Canteen lunch
Afternoon snack	Packed lunch
Evening meal	Street lunch
Evening snack	Dinner

2.2.5.) *Definition of meals and portion sizes*

The definition of eating occasions – and particular of what constitutes a snack – is fraught with difficulties. The Secondary analysis of the Survey of Sugar intake among Children in Scotland included an investigation of their eating patterns (McNeill et al. 2009b), and a review of the literature on the definition of eating occasions. The review found great variability in the definitions, including classification by time of day, nature of food, and self-classification by the survey participant.

The review also noted that a problem associated with classification according to time of day was that the 'disordered' nature of modern life and meal patterns meant that the meals of breakfast, lunch and dinner were often taken outside the 'traditional' times. It was decided for the purposes of the present study to use classification by meal time. However, rather than using set time divisions to segregate eating occasions, the

researcher used her own judgement as to what the child considered the eating occasion to be.

For example, food eaten at home before school, or on the way to school, was considered 'breakfast'. Food consumed during morning break time was a 'snack' (no matter how large), and food consumed during the school lunch time was 'lunch'. Food consumed on the way home from school was a 'snack' (no matter how large). The largest eating occasion (in terms of amount of food consumed) after arriving home from school was defined as 'dinner'; all other food consumed separately during the evening was classed as 'snacks'.

Food and drink items from the diaries were entered into WinDiets. Where participants had written portion sizes in grams (having weighed the food, or if portion size was labelled on the packaging) this information was entered. Sometimes children provided the food's brand name and size, and the researcher used this to obtain the actual portion's weight in grams from product packaging or manufacturers. Otherwise, portion sizes were estimated using *Food Portion Sizes* (Food Standards Agency 2002a), with the following exceptions.

Before the study commenced, the researcher visited the school canteens to meet with kitchen staff and determine the portion sizes of prepared dishes (including sandwiches, wraps and filled rolls), and to record the portion or pack sizes of manufactured foods and drinks.

The children purchasing street lunches often took advantage of 'meal deals' offered by a local baker, and including items such as jumbo sausage rolls and doughnuts. These were observed to be significantly larger than the portion sizes described in *Food Portion Sizes* (Food Standards Agency 2002a), so an example of each item was purchased and weighed.

2.2.6) *Novel foods and recipes*

WinDiets uses the Royal Society of Chemistry's database of food (Food Standards Agency 2002b), which omits several manufactured foods eaten by the children, for example pot noodles. WinDiets allows the addition of novel foods to its database, and where possible information from packaging or manufacturers was used to create new entries for foods not included in the existing database.

WinDiets also enables the creation of 'recipes', whereby the user can enter individual ingredients to create a recipe that can then be searched for and used in data entry in the same way as other foods in the database. This procedure was used for dishes and food items such as cooked dishes on canteen menus, the wide variety of sandwiches, wraps and filled rolls available in the schools and from vendors outside the school premises, and meals cooked at home (where WinDiets did not already contain an entry for a dish, or the researcher was unable to directly obtain a list of ingredients and quantities, a recipe from a standard recipe book was used to create a new entry in WinDiets).

2.2.7) *Selection of nutrients for consideration*

WinDiets analyses food data for a list of 40 nutrients plus energy, as follows: energy (kcal), fat, saturated fat, monounsaturated fat, polyunsaturated fat, protein, carbohydrates, sugars, starch, non-milk extrinsic sugars, non-starch polysaccharides, alcohol, water, vitamin A, thiamine, riboflavin, niacin, vitamin B6, vitamin B12, folate, biotin, vitamin C, vitamin D, vitamin E, calcium, magnesium, sodium, potassium, chloride, phosphorus, iron, zinc, copper, manganese, selenium, iodine, dietary fibre, cholesterol, retinol, carotene.

The Scottish Nutrient Standards for School Lunches in place at the time of the study (Crawley 2005b) included standards for the following nutrients: Kcal, fat, SFA, NMES and sodium (for which the standards were maximum values), plus protein,

carbohydrates, NSP, vitamin A, folate, iron, calcium and fruit and vegetable portions (for which the standards are minimum values).

In order to limit statistical analysis to manageable proportions, and since this study is largely concerned with school meal choices and their influence on overall nutrient intake, it was decided to consider energy, 8 nutrients, plus fruit/vegetables, selected from those covered by the SNSSL for the purposes of this study, namely:

- Energy (kcal)
- Fat
- Saturated fat (SFA)
- Non-milk extrinsic sugars (NMES)
- Fibre/Non-starch polysaccharides (NSP)
- Vitamin A
- Folate
- Calcium
- Iron
- Fruit and vegetable portions

The following nutrients, and percentages of energy obtained from nutrients, were also analysed for the total daily intake (whole sample, as well as sample split according to lunch type) see Tables 18 and 21.

- Protein
- Carbohydrate (CHO)
- % energy from fat
- % energy from saturated fat (SFA)
- % energy from non-milk extrinsic sugars (NMES)
- Vitamin C

Carbohydrates, protein and vitamin C were not included in the full statistical analysis for the following reasons:

Previous research (see section on other studies on children's diets (sections 1.1.2., 1.1.3.), and children's lunches (sections 1.7.1., 1.8.1., 1.9.), as well a report from the National Forum for Coronary Heart Disease Prevention (National Forum for Coronary Heart Disease Prevention 1993) has found children's intakes of carbohydrate, protein, and vitamin C to be adequate.

Children appear to obtain much of their vitamin C from potato products rather than fruit and vegetables, which are notably lacking from their diets (Gregory & Lowe 2000). This suggests that measuring fruit and vegetable intake could be more valuable than measuring vitamin C intake. In addition, the researcher's previous work on street lunches (Norris 2005) had suggested that street lunches were particularly likely to be deficient in fruit and vegetables. For these reasons, as well as their nutritional and health importance, and concerns about children's intake, fruit and vegetable portions were included in the statistical analysis for the present study, despite being foods rather than nutrients).

The studies cited in the section of this thesis concerning other studies on children's diets and children's lunches also found high intakes of sodium and salt, often above the recommended levels. However, sodium was omitted from the analysis for the present study because it was decided that it was not practical to expect children to accurately record the amount of salt they added to food, or know the amount of salt in foods prepared for them. There would also be considerable error introduced by the variability of sodium contents in brands of manufactured foods. The NDNS for children (Gregory & Lowe 2000) estimated sodium intakes from urine sodium levels, but this was not possible in the current study since urine could not be collected.

2.2.8) *Comparative / pilot study*

During May 2005, as part of an MSc thesis (Norris. 2005), the researcher had conducted a smaller study at a different secondary school in Dunfermline, Fife, using food diaries to record foods consumed at lunchtime by pupils choosing to buy their own

lunch outside school (street lunch), as well as a questionnaire investigating children's motivation for purchasing their own lunch outside school premises.

Table 9: Sample size and breakdown for pilot study:

		Gender		Total
		Male	Female	
School year	S2	10	7	17
	S3	3	4	7
Total		13	11	24

Source: (Norris 2005)

The food diary prototype used, along with its explanatory notes, was found to be appropriate for the age group, who appeared (from a home economics lesson conducted before the study) able to estimate portion sizes with adequate accuracy.

However, the pilot study investigated the lunchtime meal only, so for the present study the diary design was expanded to cover all food and drink eaten over 5 days, and adapted from an A4 design to a smaller A5 layout, to make it easier for the children to carry the diaries with them throughout the day.

2.3) Statistical analysis – creation of databases

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) Version 16.0.1 (SPSS Inc. 2007).

Creation of database 1 – each case representing one child

Database 1

A database was created with each case representing a child (n = 332). Variables were created to identify the child, the school they attended, their age, and their intakes of the nutrients and foods considered by this study, on each of the days when data was

collected. To enable categorisation of the children, a variable was created for whether they habitually had canteen, packed or street lunches (on four or more of the five study days).

However, upon examining database 1, it was noted that data analysis was complicated by the fact that a high proportion of the children did not have a habitual lunch type, but rather 'flitted' between canteen, packed and street lunches.

The question then arose of how to treat data from those children who did not habitually choose the same lunch option for four or more days. One option would be to relax the criterion for classifying a child as 'habitual', in order to categorise every child as having a 'habitual lunch choice' of canteen, packed or street, and analyse their entire intake (of up to five days' data) as the allocated 'habitual' lunch type (for example canteen), even on days when other lunch types were consumed. For example, a child having a canteen lunch on four days, and a packed lunch on one day, would be categorised as 'canteen' for all five days. This would have severely compromised the validity of the study. Also, personal observation by the author, along with informal discussions with children during the pilot study, suggested that this would be a misleading approach, as these 'non-habitual' children did not favour one lunch type over another.

Another option would have been to disregard the data from children not having a habitual lunch choice (not choosing the same option on four or more days). This was decided against because analysis on this basis would exclude a large amount of data concerning lunches eaten by children who 'flitted' from one lunch type to another (38.6% of the study participants).

Creation of database 2 – each case representing one day's food intake

For the above reasons it was decided to consider each day as the unit of sampling, rather than each child. Because of this decision to use 'days' as the unit of sampling, database 1 was used to construct a second database (database 2), to be used for the statistical analysis required for the present study. This meant that each child contributed several days to the analysis, and the impact of the children's lunch choice on a particular day could be examined.

It was accepted that this approach would not take into consideration potential data on individual children's motivation and choices, but would provide a better analysis of the nutrient intake (the focus of the present study) on days when a particular behaviour pattern – the choice of a canteen, packed or street lunch – was chosen. The child-based data (database 1) was retained in the hope of the opportunity for analysis in the future.

Database 2 - Data was entered by the researcher to create a database with each case representing a day.

Each child contributed 1 – 5 days' data (see table 14), to make a total of 1,532 cases (days of data).

The variables were as follows: Case number, Unique child code, School, Number of days' diary completed, Number of days' Canteen lunch, Number of days' Packed lunch, Number of days' Street lunch, Number of days' Mixed lunch, Gender.

Then for each Lunch type (canteen, packed, street): Energy (kcal), Protein (g), Total carbohydrate (g), Total fat (g), % energy from fat, SFA (g), % energy from SFA, NMES (g), % energy from NMES, NSP (g), Vitamin C, Vitamin A (ug), Folate (ug), Calcium (mg), Iron (mg), Fruit/vegetables (portions).

For 'total lunch intake' (intake from canteen + packed + street for that day), a variable column for energy, each of the 8 nutrients, plus fruit/vegetables, was created.

Then for 'total day's intake, a variable column for energy, each of the 8 nutrients, plus fruit/vegetables, was created.

As well as examining nutrient intake, it was decided to consider nutrient density, to provide an alternative measure of 'nutritional adequacy', and means of comparison between the lunch types, and days including them. Variables were calculated in SPSS, for the nutrient density of each of the lunches analysed in the present study, and the

nutrient density of the whole day's intake (on days when canteen, packed and street lunches were eaten). Nutrient densities were calculated in terms of grams, milligrams or micrograms per 100kcal.

Because lunchtime intake data would need to be compared with the SNSSL requirements (Scottish Executive 2003b) for energy, each nutrient, plus fruit and vegetables, variables were created for these SNSSL requirements, to enable this. Variables were created for EAR, DRV, RNI and LRNI (as appropriate) (Department of Health 2003b), and the Government recommendation for fruit and vegetables (Department of Health 2003a) to enable comparison of total daily intake data with these guidelines.

To provide a 'target' to compare lunchtime nutrient density data with, the nutrient densities were calculated (for each nutrient analysed in the present study) for a hypothetical lunch that precisely met the SNSSL requirements. These hypothetical 'targets' were then created as variables in SPSS, to enable the comparison between actual nutrient density and the 'targets'.

A similar comparison was required for the 'whole day' data. For each nutrient, the nutrient density of a hypothetical day that exactly met the EAR, DRV or Government recommendation, was calculated, and created as a variable in SPSS. This enabled comparison of the sample's daily nutrient density with these hypothetical 'targets'.

To determine the percentage of canteen, packed and street lunches, that met the SNSSL standards, new variables were created, coded '0' for a lunch failing to meet the standard and '1' for lunches meeting the standard. To determine the percentage of days where canteen, packed and street lunches were consumed, that met the EAR, DRV or Government recommendation (whichever was applicable) new variables were created, coded '0' for a day failing to meet the standard and '1' for days meeting the standard.

Unique child codes were created to provide an at-a-glance summary of the child's characteristics for the researcher. The first element of the code was a number, allocated sequentially from 1. Next came a letter representing the child's gender (M =

male, F = female). This was followed by the child's age in numbers. Then came a letter representing the School (Q = Queen Anne High School, S = St Columba's High School). Finally, after an underscore to aid clarity of reading, numbers and letters were added to represent the number of days on which the child had each lunch type: canteen (C), packed (P), street (S) or mixed (M).

Two examples of unique child codes included:

44M13Q_5C (child number 44, male, aged 13, from Queen Anne High School, who had 5 canteen lunches).

292F12S_1C4S (child number 292, female, aged 12, from St Columba's High School, who had 1 canteen lunch and 4 street lunches).

If no data was available for a variable, 9999 was entered, to represent 'no data', rather than a value of zero (because zero is a 'real' figure, it would have influenced the statistical analysis).

Examples of 9999 codings included a variable related to the packed lunch contribution to a nutrient when all food consumed by the child that lunchtime was purchased from the canteen. A 9999 coding was also allocated to every variable column for Day 5, if a child only completed 4 days of diary. If a child purchased food from, for example, both the canteen and shops outside the school, data was entered in the variable columns representing nutrient intakes from canteen and street, but 9999 was entered in the variable columns for packed lunch contributions.

Habitual lunchtypes were coded as follows: 1 = Canteen, 2 = Packed, 3 = Street, 4 = Non-habitual. Children were allocated a Habitual lunch type (1 – 3) if they had that lunch type four or more times during the five-day study period.

2.4) Statistical tests used

Descriptive statistics (mean and standard deviation) were compiled for the whole sample, and for the sample subdivided by choice of lunch type.

2.4.1) Statistical analysis of lunch data

One-sample T-tests were used to compare the mean nutrient intakes for the lunch type groups, with the SNSSL standards. Mean nutrient intakes for each lunch type were expressed as a percentage of the SNSSL targets.

One-way between-sample ANOVA tests were used to detect any significant difference in terms of nutrient intake, between canteen, packed and street lunches. If a significant difference was found, post-hoc tests (Tukey's test) were used to determine the location of that significant difference, between canteen and packed lunches, canteen and street lunches, and packed and street lunches.

The mean nutrient densities of canteen, packed and street lunches were also compared with the nutrient densities of a hypothetical lunch which exactly met the standards of the SNSSL. In addition, one-way between-sample ANOVA tests were used to detect any significant difference in nutrient density, between canteen, packed and street lunches, followed by post-hoc tests (Tukey's test) to determine the location of any significant difference in nutrient density, between the lunch types.

2.4.2) Statistical analysis of total daily intake data

Descriptive statistics (mean and standard deviation) were calculated for the total daily intake of energy, protein, total carbohydrate (CHO), fat, % energy from fat, SFA, % energy from SFA, NMES, % energy from NMES, NSP, vitamin C, vitamin A, folate,

calcium, iron, and fruit and vegetables) for the sample as a whole. Descriptive statistics for the energy, nutrients, and fruit and vegetables listed above, were also calculated, split according to the lunch type (canteen, packed or street) consumed on each particular day.

Mean total daily intakes of energy, fat, SFA, NMES, NSP, vitamin A, folate, calcium, iron, and fruit and vegetables, were also compared with each nutrient's DRV (in the form of EAR, RNI and (where applicable) LRNI, plus the Government recommendation for fruit and vegetable intake). The mean intake as a percentage of the EAR, DRV, RNI, LRNI (where appropriate) or recommendation was calculated, and also the percentage of the sample meeting those targets.

Nutrient densities for the appropriate nutrients were calculated for the sample as a whole. While lunch data had been compared with a hypothetical lunch meeting the SNSSL requirements, total daily nutrient density was compared with a hypothetical day meeting the DRV (EAR, RNI, LRNI (where applicable) and Government recommendation for fruit and vegetables).

The data was then subdivided by lunch type (canteen, packed, street) and the same statistical tests as were used for lunchtime intake data were also conducted for the total daily nutrient intake, with comparisons between days including the three lunch types. Nutrient density was examined in the same way. Where lunchtime intake data had been compared with the SNSSL requirements, total daily intake data was compared with the DRV.

2.4.3) Statistical analysis of the Influence of lunchtime intake on that for the whole day

To ascertain the importance of the lunchtime meal in terms of its contribution towards total nutrient intake, the percentage of total daily intake provided by lunch was calculated for canteen, packed and street lunches.

The mean intake of the study sample as a percentage of appropriate standard (SNSSL or DRV), for lunchtime and the whole day, and split for lunch type, was then calculated, as well as the percentage of the sample (split according to lunch type) that met the appropriate standards. This was to determine whether, for example, a certain lunch type was unsuccessful at meeting the SNSSL standard at lunchtime, but by the end of the day the DRV was achieved, indicating that food intake at other times had compensated for poor nutritional intake during lunchtime.

The percentage of the sample – split according to whether canteen, packed and street lunches were consumed – meeting the appropriate standards (SNSSL for lunchtime, or EAR, DRV or Government recommendation), was also calculated.

Chapter 3 – Results

3.1) Description of sample

Figure 1 (following page) shows the number of subjects recruited and lost to the study at each stage. Phase 1 involved S2 pupils (age 12 - 13), and data collection took place in the autumn term of 2007. Phase 2 took involved S1 pupils (age 11 – 12) at St Columba's High School, and S3 pupils (age 13 – 14) at Queen Anne High School. Data collection for Phase 2 took place during January and February 2008.

Food diaries were given to 953 children in total. The final stage of data collection, where pupils had to return their completed diaries, produced greatest attrition of the sample size. The number of completed diaries returned was 376 (39.4% of diaries distributed).

Several diaries were rejected by the researcher on the grounds of illegibility, failure to provide sufficiently detailed information, obvious omissions (for example lack of inclusion of any drinks) or stopping recording partway through the day. If pupils recorded weekend days in addition to week days, the weekend data was discarded, but the weekday data was included in the analysis.

Total sample = 332 children.

Table 10: Breakdown of final sample of completed and acceptable diaries

	Queen Anne	St Columba's	Total
Boys	100	50	150
Girls	113	69	182
Total	213	119	332

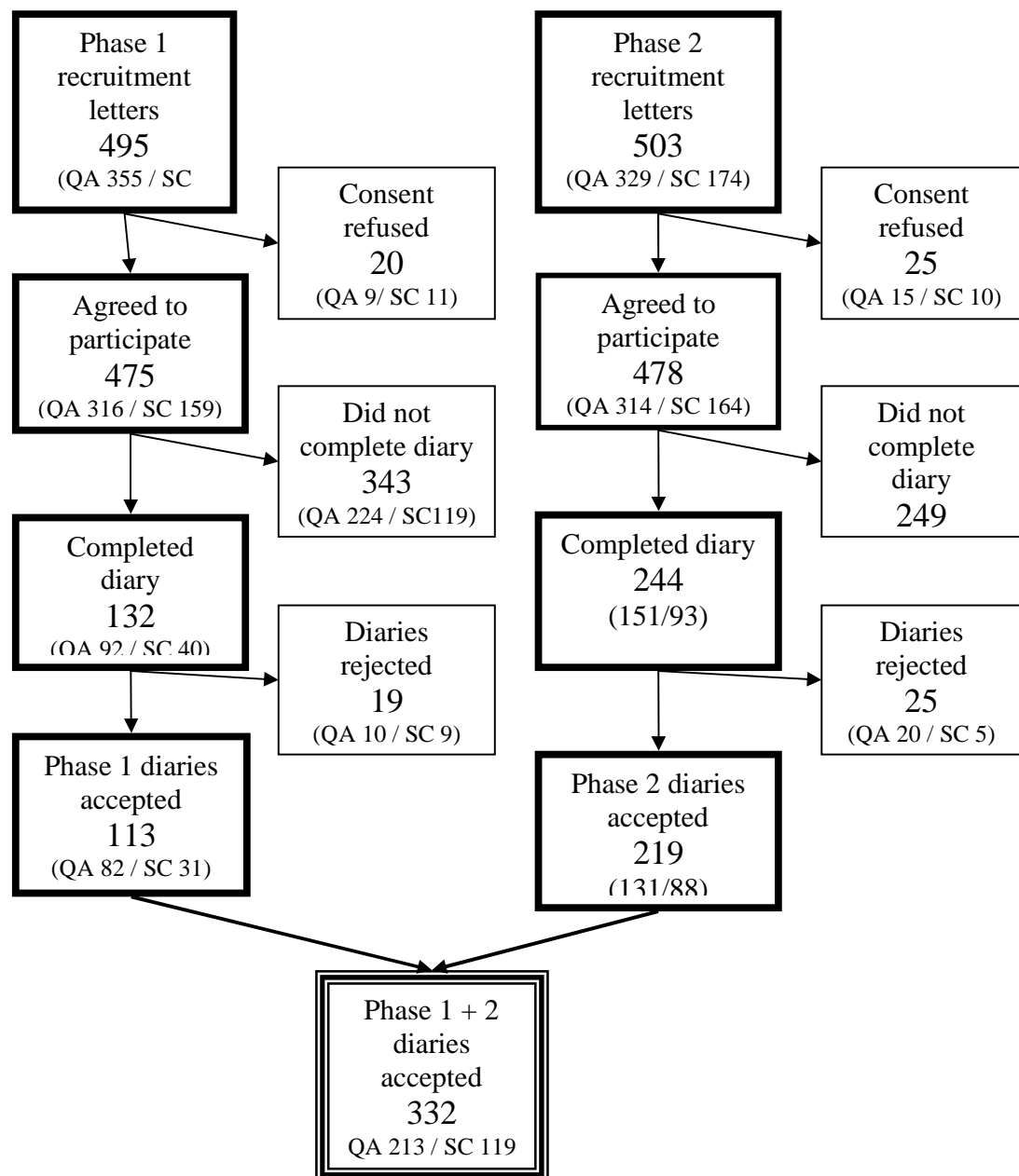


Figure 1: Flow chart of number of subjects recruited and lost to the study at each stage
 QA = Queen Anne High School SC = St Columba High School

3.1.1) *Confirmation of the decision not to split analysis by gender*

Because the present study was concerned with comparisons between the influence of lunch choice (canteen, packed or street) on nutrition, rather than the influence of gender on nutrition, it had been previously decided not to analyse data from males and females separately. However, the researcher was aware that if the numbers of days recorded by males and females were significantly different (for example, if many more street lunches were consumed by boys), this would skew the overall results of the analysis. In the event, the number of male and female days in each lunch group were extremely similar. It was therefore accepted that the effect of gender would not substantially affect the results of the study.

Table 11: Number of days' data from males and females

			LUNCH TYPE			
			CANTEEN	PACKED	STREET	TOTAL
Sex	Male	Count	323	144	195	662
		%	48.8%	21.8%	29.5%	100.0%
	Female	Count	362	165	209	736
		%	49.2%	22.4%	28.4%	100.0%

3.1.2) *Consideration of extreme values*

After thoroughly checking the database for errors, extreme values remained. These were not excluded from statistical analysis for the following reasons.

It is usually assumed that a dietician will recognise implausible data (McNeill et al. 1991). Observation of the children (in school and outside school premises) by the researcher, and information obtained via interviews with school canteen staff and teachers, also suggested that some children's diets were indeed 'extreme', with several

buying the equivalent in food of two or more lunches, or buying lunches consisting solely of foods such as chocolate, doughnuts and fizzy drinks, which will have resulted in consumption of large amounts of (in this example) sugar. Also, several children purchased a lunch-sized meal during their morning break, and another at lunchtime. Conversely, other children's food intake was very low, though their food diaries were carefully completed, with eating occasions throughout the day, suggesting that their food intake was indeed low, rather than that food was being omitted from records due to boredom or lack of time.

Super- and under-consumers also existed regarding individual nutrients, a problem also noted in a study of 1,909 school lunches (Lambert et al. 2005a). These individuals skew the data, as well as potentially creating nutritional problems for themselves. However, since observation of the children during the pilot study and prior to the present study suggested that some children do eat extreme diets, it was decided that excluding them would introduce sample bias. It was also decided that these children were interesting and relevant and deserved study.

It was also concluded that the large sample size of the present study would negate any disproportionate effect exerted by individuals consuming diets 'extreme' in any aspect.

3.1.3) Consideration of number of days' data

Seventy-nine percent of participants completed food diaries for 5 days. However, some pupils completed records for fewer days. For example, some children had included weekend intake which had to be discounted, and others presumably became bored with recording before finishing the study period. (Children assumed to have ceased recording due to boredom were still considered trustworthy recorders if their previous days' data appeared feasible).

However many day's diary a child completed, a day was included in the analysis if it was judged by the researcher to be trustworthy on the basis of feasibility. This decision was made in order to maximise the size of the number of days available for analysis.

Table 12: Number of children completing 5, 4, 3, 2 or 1 day of records

School	Number of days' record				
	5	4	3	2	1
Queen Anne	181	12	11	6	2
St Columba's	80	15	21	2	1
Total	261	28	32	8	3

Table 13: Total number of days' data for Canteen, Packed and Street lunches

Lunch type	Number of days' data	% of days' data recorded
Canteen	685	44.7
Packed	309	20.2
Street	404	26.4

3.1.4) *Habitual lunch choices*

Previous studies on children's lunchtime food and nutrient intakes tended to show children habitually taking the same lunch option (for example canteen or packed lunch) every day, or almost every day (Department of Health 1989). It soon became apparent when analysing data from the present study that many children did not have the same type of lunch – canteen, packed or street - every day.

Table 14: Habitual lunch choices in the present study

		Habitual lunch type				
		Canteen	Packed	Street	Not habitual	Total
Sex	Male	47	23	23	57	150
	Female	63	27	22	71	182
	Total	109 (32.8%)	50 (15.1%)	45 (13.6%)	128 (38.6%)	332

(Figures represent number of children)

It had initially been considered to categorise children as 'habitually' having a lunch type (canteen, packed or street) if they had that lunch type on four or more days of the study. For this purpose, a database (database 1) was constructed (see 2.3), with each case representing a child, with variables for the lunch type (or types) consumed, their nutrient intakes at lunchtime, as well as for their total daily intake, for each day recorded.

However, because of the large proportion of children not habitually having the same lunch type, it was decided to consider each day as the unit of sampling (with each child contributing several days' data to the analysis), rather than each child (see 2.3). Database 1 was used to construct a second database (database 2), to be used for the statistical analysis required for the present study.

3.1.5) *Mixed lunches*

In addition, some lunches comprised food from more than one lunch type, for example a child who had a school (canteen) lunch but supplemented it with food purchased outside school (street lunch), or one who brought a packed lunch but also purchased one or more items from the canteen. These lunches were categorised as 'Mixed'. Although it would have been possible for a child to have food from all three sources, this did not occur in this study, and all mixed lunches were made up of canteen plus packed, canteen plus street, or packed plus street. A further category of 'skipped' lunches was included for children who completed a full day's food diary but had no food at lunchtime.

Table 15: Total number of days' data for 'mixed' lunches, plus number of 'skipped' lunches

Lunch type	Frequency	Percentage of total sample
Canteen + Packed	55	3.6%
Canteen + Street	52	3.4%
Packed + Street	19	1.2%
Skipped	8	0.5%
Total mixed	134	8.7

The small number of mixed and skipped lunches were excluded from the statistical analysis, though their relevance is noted in the Discussion/Conclusion of this thesis.

3.1.6) *Selection of statistical tests for lunch analysis*

The vast amount of information in the database presented challenges regarding how best to represent the data. Kolmogorov-Smirnov tests suggested violation of the assumption of normal distribution for the sample. The greatest violation was seen for fruit and vegetable intake (see Appendices).

However, parametric rather than non-parametric statistics were selected for analysis, for the following reasons:

The sample was drawn from a population (the population of children in Scotland) which would be expected to show a normal distribution. In addition, other studies (see Literature review) on children's diets almost exclusively utilise parametric statistics. The large sample size of the present study (1,398 'pure' (not mixed lunch type) meals) means that a Gaussian distribution is not necessary to indicate suitability of parametric statistics.

As noted above, because of the extremely high variability of the nature of 'mixed' lunches, only 'pure' (solely canteen, packed or street) lunches were considered for comparison with the nutrient targets. Mixed lunches only provided a small proportion (8.7%) of the sample.

For this analysis, Database 2 was used. To exclude the days where mixed lunches were consumed, SPSS was used to filter the data to include only cases where the variable for Lunch type was represented by the codings 1 – 3, representing food input from solely canteen, packed or street lunch food.

3.2) Analysis of lunchtime nutrient intake data

Descriptive statistics were calculated for energy, the 8 nutrient values, plus fruit/vegetables, for the three lunch types: canteen, packed and street. One sample T-tests were used to compare mean nutrient intakes for each lunch type with the SNSSL, to determine whether there was a significant difference between the actual lunchtime intake and the standard

Table 16: Nutrient intake, mean and standard deviation (SD), plus comparison with SNSSL requirements: canteen, packed and street lunches

NUTRIENT [SNSSL req]		CANTEEN	PACKED	STREET
Energy (kcal) [646kcal]	Mean (SD)	504 (237)	556 (203)	707 (293)
	P value	p < 0.001	P < 0.001	p < 0.001
Fat (g) [25.1g]	Mean (SD)	18.1 (10.5)	26.0 (13.5)	32.2 (16.4)
	P value	p < 0.001	NS	p < 0.001
SFA (g) [7.9g]	Mean (SD)	7.6 (5.3)	11.8 (8.2)	10.8 (6.5)
	P value	NS	P < 0.001	p < 0.001
NMES (g) [18.0g]	Mean (SD)	15.8 (13.7)	24.7 (21.8)	35.4 (30.8)
	P value	p < 0.001	P < 0.001	p < 0.001
NSP (g) [5.2g]	Mean (SD)	3.0 (1.9)	2.6 (1.6)	2.8 (2.1)
	P value	p < 0.001	P < 0.001	p < 0.001
Vitamin A (ug) [185ug]	Mean (SD)	129 (148)	210 (168)	97 (151)
	P value	p < 0.001	NS	p < 0.001
Folate (ug) [80ug]	Mean (SD)	50 (29)	40 (29)	30 (30)
	P value	p < 0.001	P < 0.001	p < 0.001
Calcium (mg) [350mg]	Mean (SD)	237 (166)	221 (176)	176 (178)
	P value	p < 0.001	P < 0.001	p < 0.001
Iron (mg) [5.9mg]	Mean (SD)	2.1 (1.1)	1.9 (1.0)	2.0 (1.3)
	P value	p < 0.001	P < 0.001	p < 0.001
Fruit/veg (portions) [2 portions]	Mean (SD)	0.28 (0.53)	0.48 (0.65)	0.09 (0.31)
	P value	p < 0.001	P < 0.001	p < 0.001

[Square brackets indicate SNSSL requirement] SD = standard deviation NS = not significant

3.2.1) Comparison of mean nutrient intakes for canteen, packed and street lunches, with the SNSSL targets

Energy intake compared with SNSSL

The mean energy intake for all three lunch types showed a statistically significant difference ($p < 0.001$) from the SNSSL. Canteen and packed lunches had a lower mean intake than the standard, while that for street lunches (the highest intake) was higher than the SNSSL.

Fat intake compared with SNSSL

The mean fat intake for canteen and street lunches showed a statistically significant difference ($p < 0.001$) from the SNSSL, with canteen lunches having the lowest intake and street lunches the highest. Canteen lunches were significantly lower in fat than the maximum value set by the standard. The mean fat intake for packed lunches was higher than the SNSSL, but this difference was not statistically significant.

SFA intake compared with SNSSL

The mean fat intakes for packed (highest intake) and street lunches were significantly higher than the maximum value set by the SNSSL ($p < 0.001$). The mean fat intake for canteen lunches was lower than the SNSSL, but this difference was not statistically significant.

NMES intake compared with SNSSL

The mean NMES intake for all three lunch types showed a statistically significant difference ($p < 0.001$) from the SNSSL, with canteen lunches having the lowest NMES content and street lunches the highest. Canteen lunches showed intakes significantly lower than the SNSSL, and packed and street lunches were significantly higher.

NSP intake compared with SNSSL

The mean NSP intake for all three lunch types showed a statistically significant difference ($p < 0.001$) from the SNSSL, with all three lunch types showing a mean NSP intake lower than the standard. Canteen lunches had the highest intake of the three lunch types, followed by packed lunches and street lunches.

Vitamin A intake compared with SNSSL

The mean vitamin A intake for packed lunches was higher than, but not significantly different from, the SNSSL. The mean vitamin A intakes for canteen and street lunches were lower than, and showed a significant difference ($p < 0.001$) from the SNSSL standard. Canteen lunch mean intake was higher than that for street lunches, and therefore closer to the SNSSL standard.

Folate intake compared with SNSSL

The mean folate intakes for canteen, packed and street lunches were all significantly lower ($p < 0.001$) than the SNSSL standard, with canteen lunches having the highest mean intakes and street lunches the lowest.

Calcium intake compared with SNSSL

The mean calcium intakes for canteen, packed and street lunches were all significantly lower ($p < 0.001$) than the SNSSL standard, with canteen lunches having the highest intakes and street lunches the lowest.

Iron intake compared with SNSSL

The mean iron intakes for canteen, packed and street lunches were all significantly lower ($p < 0.001$) than the SNSSL standard, with canteen lunches having the highest intakes and packed lunches the lowest.

Fruit/vegetable intake compared with SNSSL

The mean fruit and vegetable intakes for canteen, packed and street lunches were all significantly lower ($p < 0.001$) than the SNSSL standard, with packed lunches having the highest intakes and street lunches the lowest. To provide a more precise indication of the extent to which the average lunch of each type met the official standards, mean lunchtime intake as a percentage of the SNSSL target was calculated.

The mean lunch intake as a percentage of the SNSSL standard for energy, fat, SFA and NMES, is shown graphically in Figure 2.

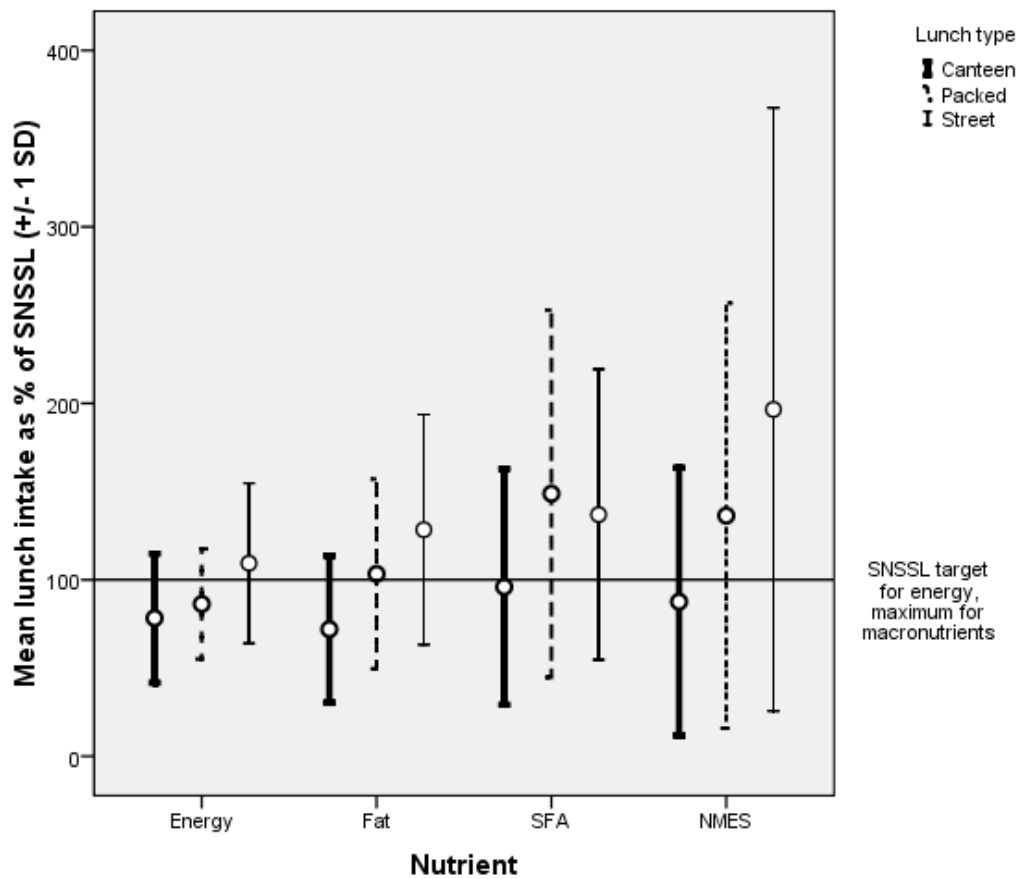


Figure 2: Mean lunch intake as a percentage of the SNSSL standard for energy, fat, SFA and NMES

The mean lunch intake as a percentage of the SNSSL standard for NSP, micronutrients, and fruit and vegetables, is shown graphically in Figure 3.

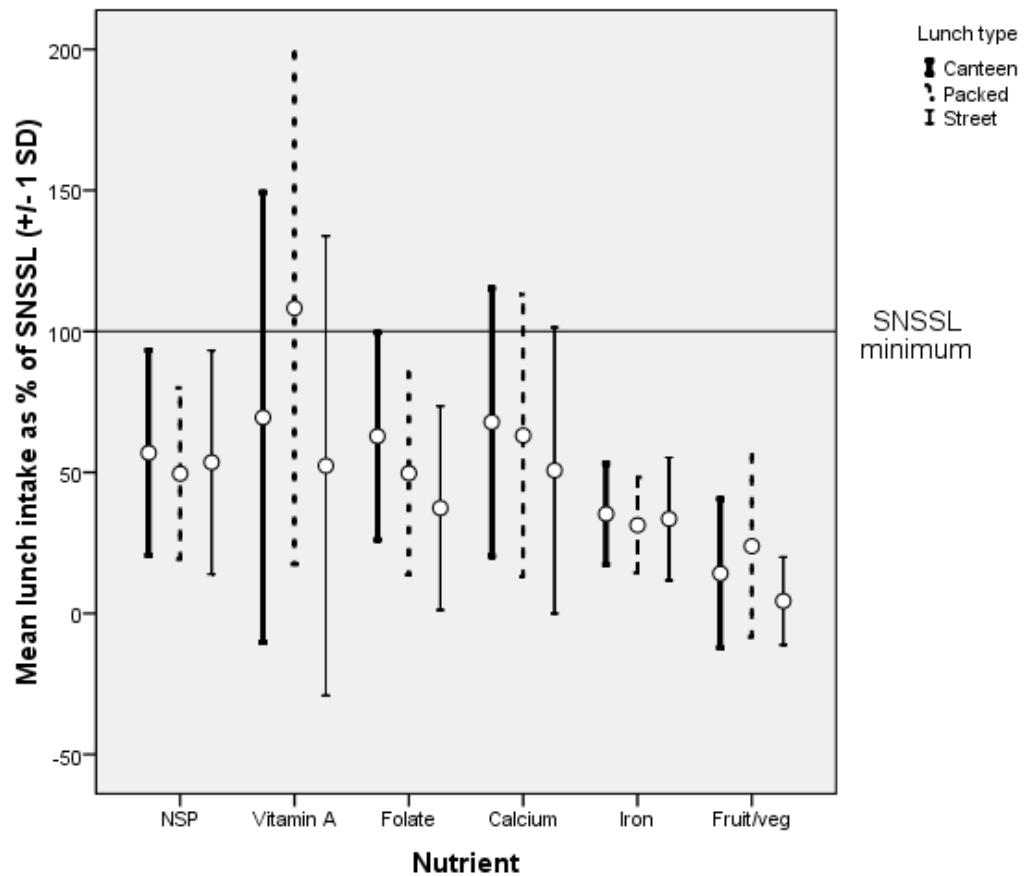


Figure 3: Mean lunch intake as a percentage of the SNSSL standard for NSP, vitamin A, folate, calcium, iron, and fruit and vegetables

3.2.2) Ranking of lunch types showing the most and least favourable nutrient intake for nutrients in the SNSSL

The most favourable nutrient intake could be the lowest (as in the case of fat, SFA and NMES) or the highest (as in NSP, vitamin A, folate, calcium, iron, and fruit and vegetables).

Canteen lunches showed the most favourable mean intake for many of the nutrients: the lowest intakes of fat, SFA and NMES, and the highest intakes for NSP, folate, calcium and iron. Canteen lunches did not show the least favourable intake for any nutrient.

Packed lunches showed the most favourable (highest) mean intake for vitamin A and fruit/vegetable portions. Packed lunches showed the least favourable intake of other nutrients: the highest intake for SFA, and the lowest for NSP and iron (however, the differences between the lunch types for NSP and iron failed to reach statistical significance).

Street lunches did not show the most favourable mean intake for any nutrient. Street lunches showed the least favourable (highest) intake of fat and NMES, and the lowest intakes of vitamin A, folate, calcium and fruit/vegetable portions.

3.2.3) Detection and location of significant differences between nutrient intakes for canteen, packed and street lunches

One-way between-groups analysis of variance (ANOVA) and Post-hoc tests (Tukey's) were used to compare the nutrient content of the three lunch types. P values indicating presence of significant difference between canteen, packed and street lunches are shown at the top left of the following figures.

For visual comparison, a horizontal line denotes the SNSSL standard for the nutrient (or fruit/vegetables). These figures do not show the P values of significant differences between lunchtime intakes and the SNSSL standards – this information can be found in section 3.2 and Table 16).

The most notable differences between lunch types were for mean fruit and vegetable content, fat content, and folate content. The nutrients where much less significant differences were seen were NSP, iron and calcium.

Each nutrient, plus NSP, and fruit and vegetables, is considered individually in the following pages:

Lunch energy content

Canteen lunches had the lowest mean energy content (504kcal), followed by packed lunches (556kcal), with street lunches having the greatest (707kcal). One-way ANOVA was conducted to compare mean energy content for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean energy contents of each lunch type were significantly different from each other group. Canteen and packed lunches both had significantly lower mean energy contents than street lunches ($p < 0.001$). The mean energy content of canteen lunches was significantly less than that for packed lunches ($p < 0.01$, $p = 0.008$).

Total lunchtime energy intake of the three lunch types is compared in Figure 5.

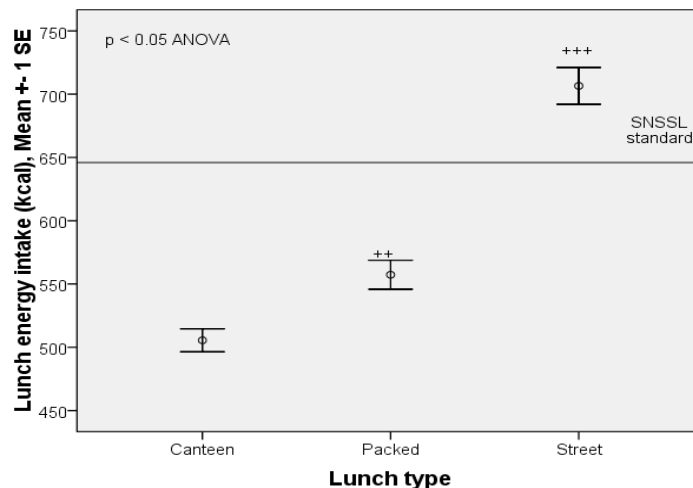


Figure 4: Total lunch energy intake (kcal) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for energy (646kcal) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

++ = $p < 0.01$ for comparison of canteen vs packed

+++ = $p < 0.001$ for comparison of street vs packed and canteen

Canteen vs packed = ++ Canteen vs street = +++ Packed vs street = +++

Lunch fat content

Canteen lunches had the lowest mean fat content (18.1g), followed by packed lunches (26g) with street lunches having the highest mean fat content (32.2g). One-way ANOVA was conducted to compare mean fat content (g) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean fat contents of each lunch type were significantly different from each other group ($p < 0.001$).

Total lunchtime fat intakes of the three lunch types are compared in Figure 5.

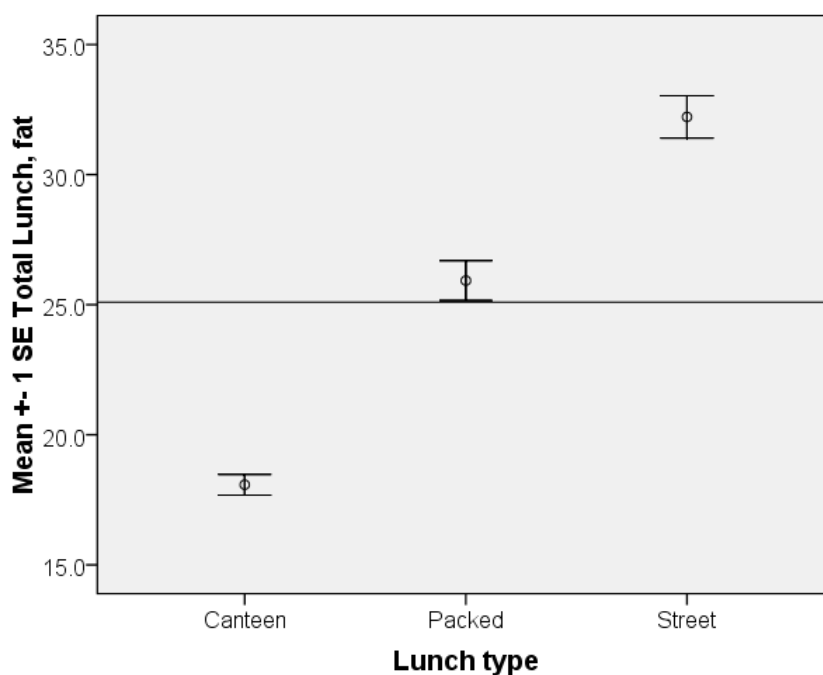


Figure 5. Total lunch fat intake (g) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for fat (25.1g) shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

+++ = $p < 0.001$ for comparison of packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Lunch SFA content

Canteen lunches had the lowest mean SFA content (7.6g), followed by street lunches (10.8g), with packed lunches having the highest (11.8g). One-way analysis of variance (ANOVA) was conducted to compare the mean SFA content (g) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons using Tukey's test indicated that the mean SFA content of canteen lunches was significantly lower than that of packed lunches and of street lunches ($p < 0.001$). The difference between the mean SFA content of packed and street lunches was not significant.

Total lunchtime SFA intake of the three lunch types is compared in Figure 6.

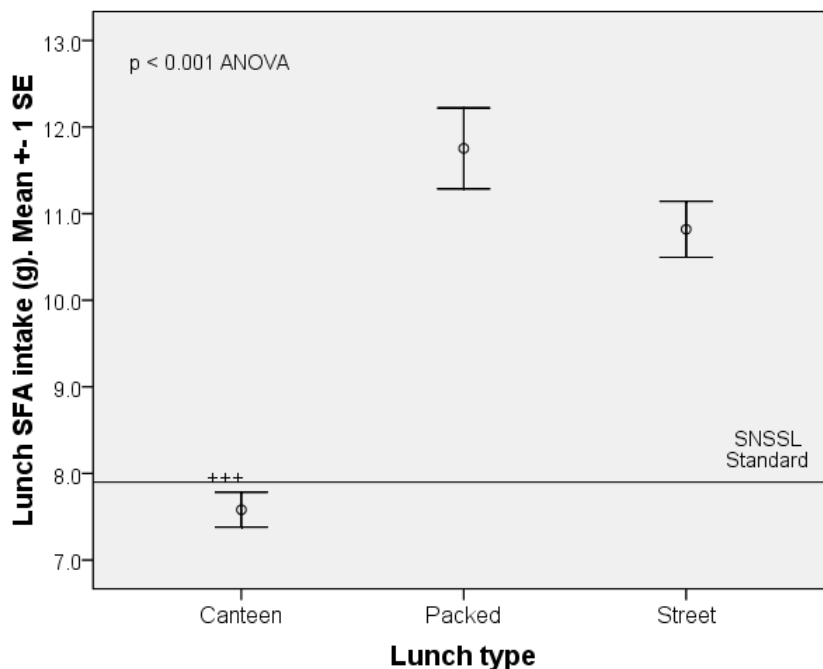


Figure 6. Total lunch SFA intake (g) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for SFA (7.9g) also shown for comparison
Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = NS

Lunch NMES content

Canteen lunches had the lowest mean NMES content (15.8g), followed by packed lunches (24.7g), with street lunches having the highest (35.4g). One-way analysis of variance (ANOVA) was conducted to compare the mean NMES content (g) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons using Tukey's test indicated that the NMES contents of each lunch type were significantly different from each other group ($p < 0.001$).

Total lunchtime NMES intake of the three lunch types is compared in Figure 7.

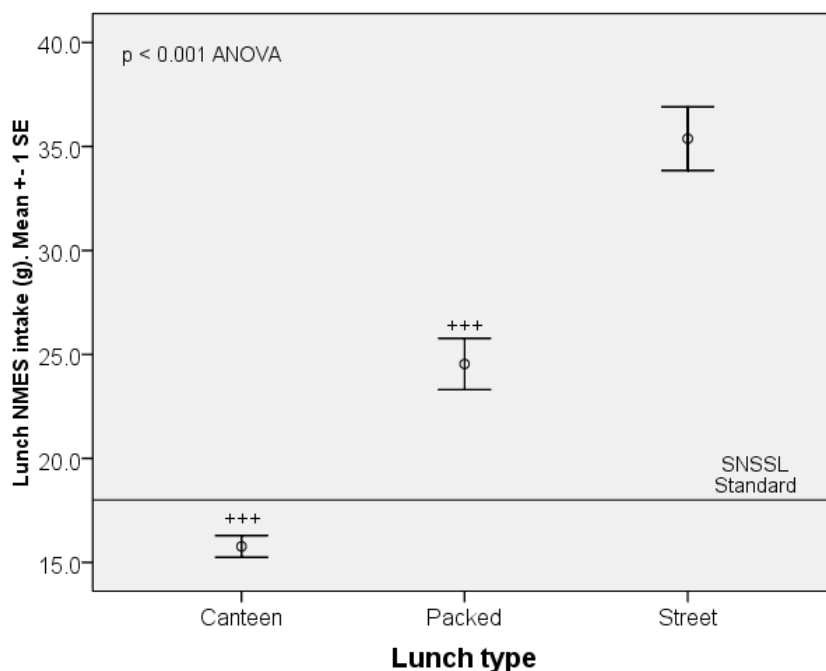


Figure 7. Total lunch NMES intake (g) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for NMES (18g) also shown for comparison. Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

+++ = $p < 0.001$ for comparison of packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Lunch NSP content

Canteen lunches had the highest mean NSP content (3g), followed by street lunches (2.8g), with packed lunches having the lowest (2.6g). One-way analysis of variance (ANOVA) was conducted to compare the mean NSP content (g) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.05$, $p = 0.011$). Post-hoc comparisons using Tukey's test indicated that the mean NSP content of canteen lunches was significantly greater than that of packed lunches ($p < 0.01$, $p = 0.008$). There was no significant difference between the mean NSP content of canteen and street lunches, and packed and street lunches.

Total lunchtime NSP intake of the three lunch types is compared in Figure 8.

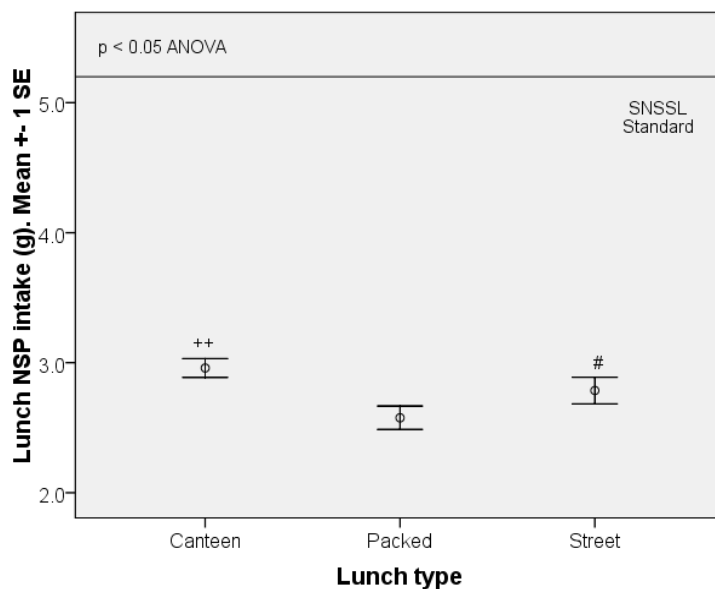


Figure 8. Total lunch NSP intake (g) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for NSP (5.2g) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

++ = $p < 0.01$ for comparison of canteen vs packed

= no significant difference for comparison of street vs packed, and street vs canteen

Canteen vs packed = ++ Canteen vs street = NS Packed vs street = NS

Lunch vitamin A content

Packed lunches had the highest mean vitamin A content (210ug), followed by canteen lunches (129ug), then street lunches (97ug). One-way analysis of variance (ANOVA) was conducted to compare the mean vitamin A content (ug) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons using Tukey's test indicated that packed lunches had a statistically significantly higher mean vitamin A content than canteen lunches and street lunches (both $p < 0.001$). Canteen lunches also had a significantly higher mean vitamin A content than street lunches, though this significance was lower ($p < 0.01$, $p = 0.003$).

Total lunchtime vitamin A intake of the three lunch types is compared in Figure 9.

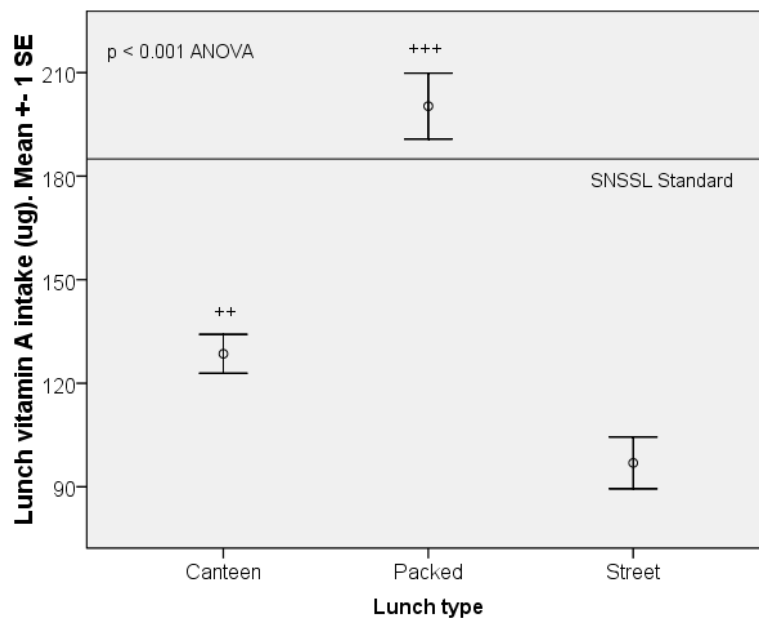


Figure 9. Total lunch vitamin A intake (ug) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for vitamin A (185ug) shown for comparison Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of packed vs canteen and street

++ = $p < 0.01$ for comparison of canteen vs street

Canteen vs packed = ++ Canteen vs street = +++ Packed vs street = +++

Lunch folate content

Canteen lunches had the highest mean folate content (50ug), followed by packed lunches (40ug), then street lunches (30ug). One-way analysis of variance (ANOVA) was conducted to compare the mean folate content (ug) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons using Tukey's test indicated that the mean folate contents of each lunch type were significantly different from each other group ($p < 0.001$).

Total lunchtime folate intake of the three lunch types is compared in Figure 10.

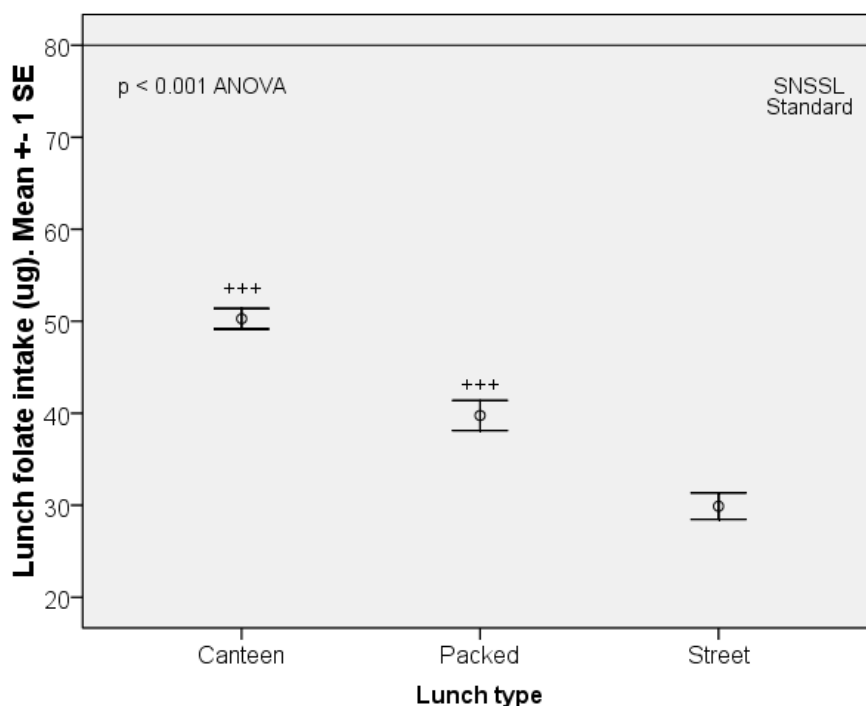


Figure 10. Total lunch folate intake (ug) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for folate (80ug) shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street, and comparison of packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Lunch calcium content

Canteen lunches had the highest mean calcium content (237mg), followed by packed lunches (221mg), then street lunches (176ug). One-way analysis of variance (ANOVA) was conducted to compare the mean calcium content (mg) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons using Tukey's test indicated that canteen lunches had a significantly higher mean calcium content than street lunches ($p < 0.001$). Packed lunches also had a significantly higher mean calcium content than street lunches, but the significance was lower than for the previous comparison ($p < 0.01$, $p = 0.003$).

Total lunchtime calcium intake of the three lunch types is compared in Figure 11.

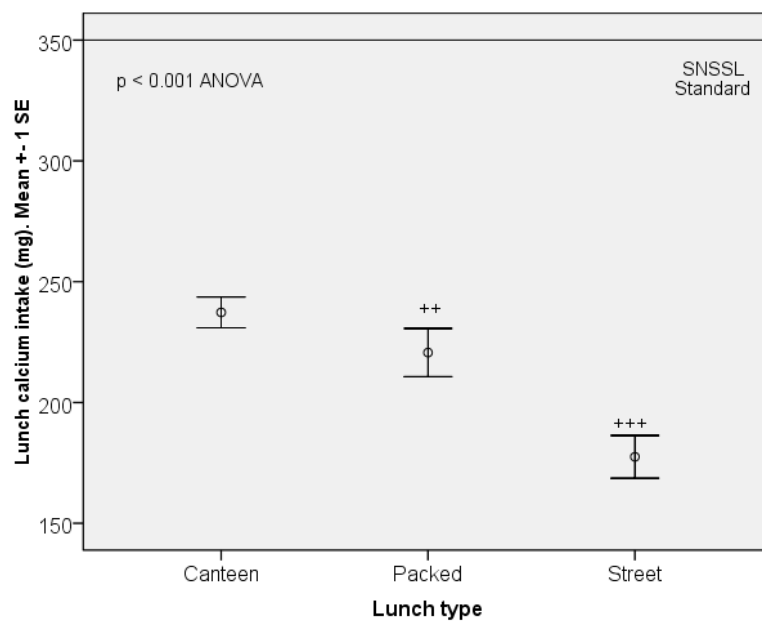


Figure 11. Total lunch calcium intake (mg) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for calcium (350mg) shown for comparison Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs street

++ = $p < 0.01$ for comparison of packed vs street

Canteen vs packed = NS Canteen vs street = +++ Packed vs street = ++

Lunch iron content

Canteen lunches had the highest mean iron content (2.1mg), followed by street lunches (2g), then packed lunches (1.9mg). One-way analysis of variance (ANOVA) was conducted to compare the mean iron content (mg) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.01$, $p = 0.009$). Post-hoc comparisons using Tukey's test indicated that canteen lunches had a significantly higher mean iron content than packed lunches ($p < 0.05$, $p = 0.007$). The difference in iron content between canteen and street lunches, and between packed and street lunches, was not significant.

Total lunchtime iron intake of the three lunch types is compared in Figure 12.

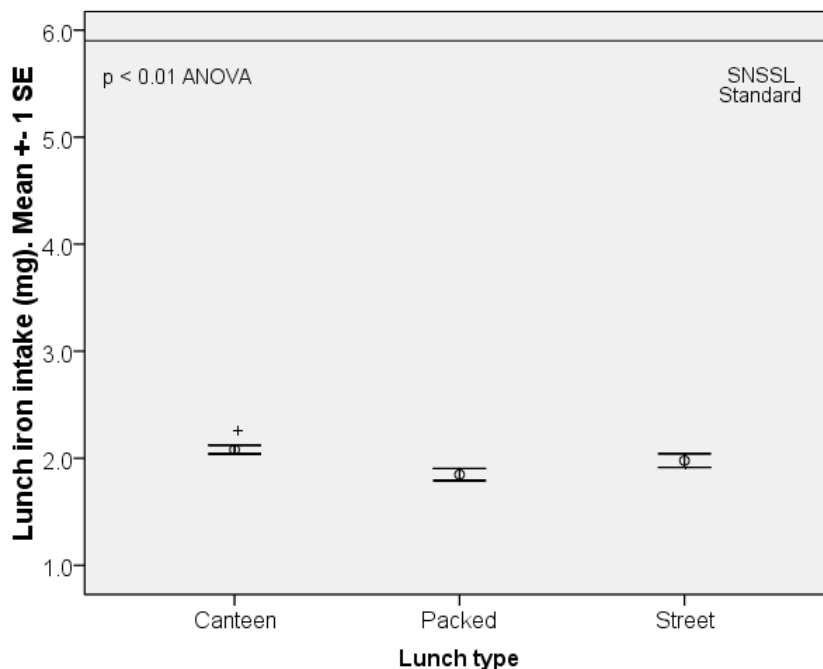


Figure 12. Total lunch iron intake (mg) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for iron (5.9mg) as shown for comparison
Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+ = $p < 0.05$ for comparison of canteen vs packed

Canteen vs packed = + Canteen vs street = NS Packed vs street = NS

Lunch fruit and vegetable content

Packed lunches had the highest mean fruit and vegetable content (0.48 portions), followed by canteen lunches (0.28 portions), then street lunches the lowest (0.09 portions). One-way analysis of variance was conducted to compare the mean fruit and vegetable content (portions) for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons using Tukey's test indicated that the mean fruit and vegetable contents of each lunch type were significantly different from each other group ($p < 0.001$).

Total lunchtime fruit/vegetable intake of the three lunch types is compared in Figure 13.

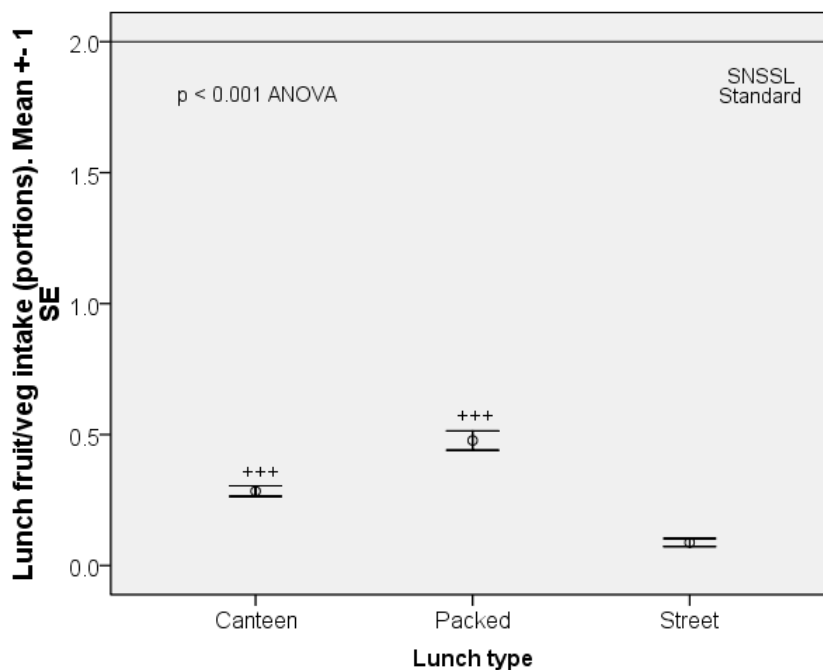


Figure 13. Total lunch fruit and vegetable intake (portions) of canteen, packed and street lunches, Standard Error of Mean. SNSSL standard for fruit/vegetables (2 portions) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street; and packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

3.2.4) Percentage of lunches meeting SNSSL targets

The percentage of lunches meeting the SNSSL standards for the nutrients and foods considered in this study is shown graphically in Figure 14.

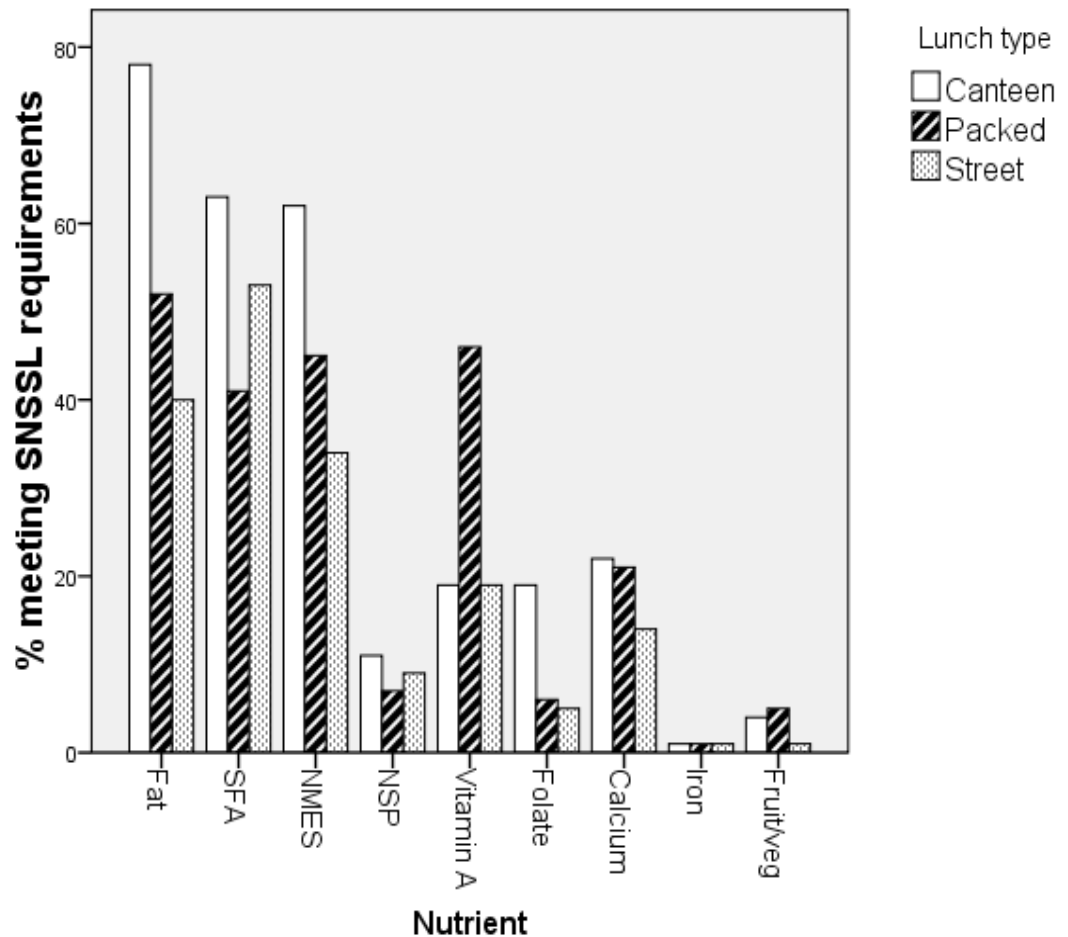


Figure 14: Percentage of canteen, packed and street lunches meeting SNSSL requirements for energy, fat, SFA, NMES, NSP, vitamin A, folate, calcium, iron, and fruit and vegetables

3.3) Analysis of lunchtime nutrient density data

It was acknowledged that if a particular lunch choice involved the consumption of large amounts of food, it would be easier to achieve nutritional standards measured in terms of quantity/intake.

To provide a method of comparing nutritional quality of canteen, packed and street lunches, nutrient density per 100kcal was calculated. To relate the present study to the SNSSL (Scottish Executive 2003b), nutrient densities for a hypothetical lunch that precisely met the SNSSL standards were also calculated, and compared with the canteen, packed and street lunches in the present study.

In order to calculate nutrient density, for each lunch type (canteen, packed and street), the mean lunchtime intake of each nutrient analysed was divided by the mean energy content (kcal). Because the nutrient intakes were measured using different units (grams, milligrams and micrograms), it was not possible to directly compare the nutrient densities of the different nutrients. Therefore, in order to provide a measure of closeness of nutrient density in the present study to the hypothetical 'target' lunch which precisely met the SNSSL, nutrient density of lunches in the study were compared with the nutrient density of the hypothetical lunch density using one-sample t-tests. Study lunch nutrient densities were also expressed as percentages of the 'target' hypothetical lunch density. To make the results of the analysis easier to interpret, nutrient densities were expressed per 100kcal.

The standard set by the SNSSL was for a lunchtime energy intake of 646kcal. In the present study, the mean energy intake was 504kcal for canteen lunches, 556kcal for packed lunches, and 707kcal for street lunches.

As an example, the SNSSL states that a lunch should contain 646 kcal and 350mg calcium. Therefore a lunch that exactly meets the SNSSL would contain $646 / 350 \times 100 = 54.18\text{mg} / 100\text{kcal}$.

Table 17: Mean lunch nutrient densities (per 100kcal): present study compared with hypothetical lunch meeting SNSSL. Significant difference between hypothetical lunch and actual intake indicated by asterisks. Standard deviation in brackets.

Nutrient	Hypothetical lunch meeting SNSSL	Canteen	Packed	Street
Fat (g/100kcal)	3.89	3.63 *** (1.50)	4.53 *** (1.48)	4.47 *** (1.41)
SFA (g/100kcal)	1.22	1.54 *** (0.87)	2.03 *** (1.12)	1.52 *** (0.75)
NMES (g/100kcal)	2.79	3.22 *** (2.87)	4.40 *** (3.62)	4.94 *** (3.83)
NSP (g/100kcal)	0.81	0.62 *** (0.39)	0.50 *** (0.34)	0.43 *** (0.36)
Vitamin A (ug/100kcal)	28.64	29.01 (36.63)	36.63 *** (32.62)	14.07 *** (25.66)
Folate (ug/100kcal)	12.38	10.18 *** (5.79)	7.93 *** (10.54)	4.36 *** (4.78)
Calcium (mg/100kcal)	54.18	47.22 *** (27.79)	38.33 *** (25.70)	24.92 *** (22.61)
Iron (mg/100kcal)	0.91	0.42 *** (0.17)	0.35 *** (1.86)	0.30 *** (0.25)
Fruit/veg (portions/100kcal)	0.31	0.07 *** (0.17)	0.10 *** (0.16)	0.03 *** (0.15)

*** = $p < 0.001$

It was noted that the standard deviation for mean vitamin A, and fruit and vegetable nutrient densities, were particularly high. This correlates with the characteristic high variability of intake for vitamin A, and fruit and vegetables, as well as the non-normal distribution of the sample data.

Lunchtime nutrient density for fat compared with hypothetical meal meeting SNSSL

Canteen lunches had a nutrient density for fat significantly lower than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). The fat densities for packed and street lunches were significantly greater than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$), with street lunches having the highest fat density.

Lunchtime nutrient density for SFA compared with hypothetical meal meeting SNSSL

All three lunch types had a SFA density significantly higher than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Packed lunches had the highest SFA density, and canteen lunches the lowest SFA density.

Lunchtime nutrient density for NMES compared with hypothetical meal meeting SNSSL

All three lunch types had a NMES density significantly higher than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Street lunches had the highest NMES density, and canteen lunches the lowest NMES density.

Lunchtime nutrient density for NSP compared with hypothetical meal meeting SNSSL

All three lunch types had a NSP density significantly lower than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Street lunches had the lowest NSP density, and canteen lunches the highest NSP density.

Lunchtime nutrient density for vitamin A compared with hypothetical meal meeting SNSSL

Packed lunches had a vitamin A density significantly higher than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Street lunches had a vitamin A density significantly lower than that for a hypothetical lunch exactly meeting the standard ($p < 0.001$). The difference between the vitamin A density for canteen lunches

and that for a hypothetical lunch exactly meeting the SNSSL standard did not reach statistical significance.

Lunchtime nutrient density for folate compared with hypothetical meal meeting SNSSL

All three lunch types had a folate density significantly lower than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Street lunches had the lowest folate density, and canteen lunches the highest folate density.

Lunchtime nutrient density for calcium compared with hypothetical meal meeting SNSSL

All three lunch types had a calcium density significantly lower than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Street lunches had the lowest calcium density, and canteen lunches the highest calcium density.

Lunchtime nutrient density for iron compared with hypothetical meal meeting SNSSL

All three lunch types had an iron density significantly lower than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Street lunches had the lowest iron density, and canteen lunches the highest iron density.

Lunchtime nutrient density for fruit and vegetables compared with hypothetical meal meeting SNSSL

All three lunch types had a NSP density significantly lower than that for a hypothetical lunch exactly meeting the SNSSL standard ($p < 0.001$). Street lunches had the lowest fruit and vegetable density, and packed lunches the highest fruit and vegetable density.

3.3.1) Comparison of lunchtime nutrient density with that of a hypothetical lunch meeting the SNSSL requirements

The nutrient densities of canteen, packed and street lunches were expressed as a percentage of the nutrient densities of the hypothetical lunch exactly meeting the SNSSL standards; this information is shown in Figures 15 and 16.

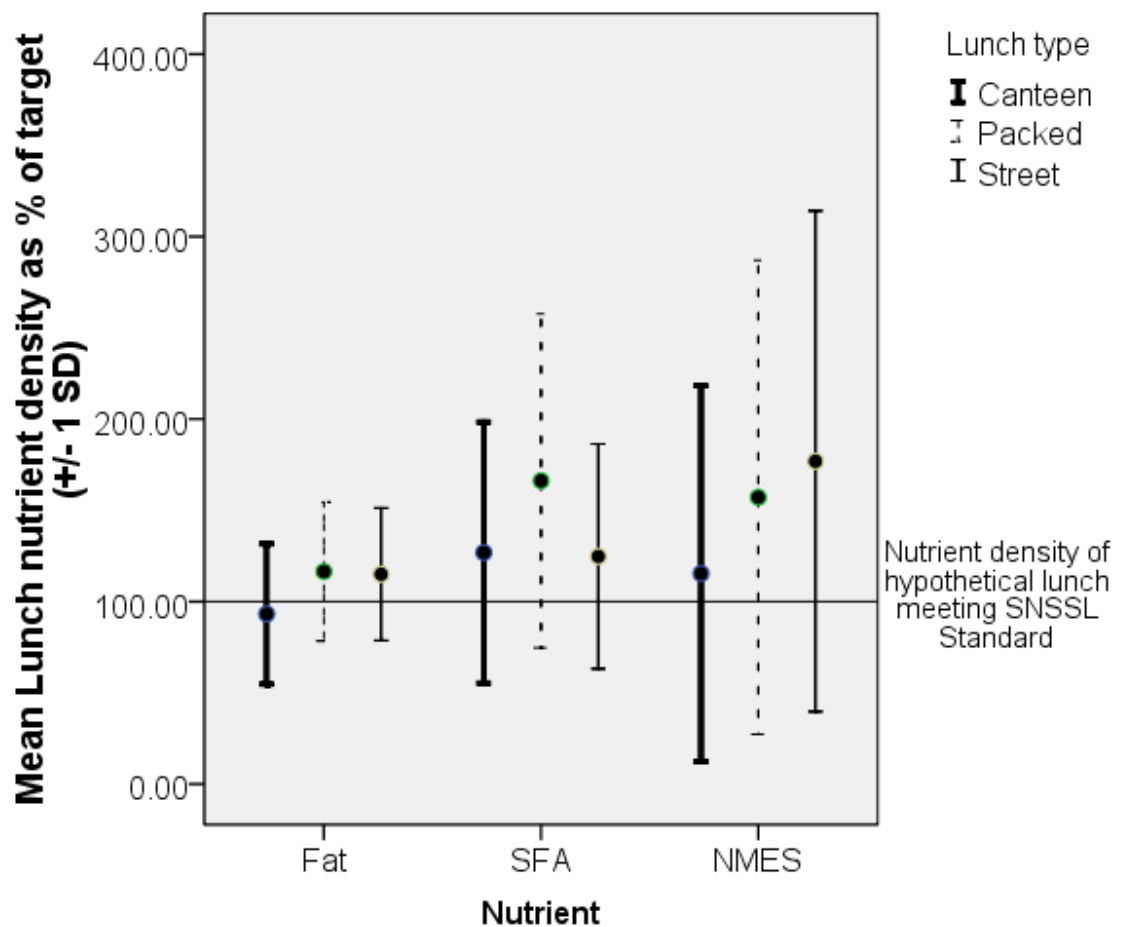


Figure 15: Mean nutrient density for canteen, packed and street lunches, as % of that provided by a lunch meeting the SNSSL requirements. Fat, SFA and NMES

The mean nutrient densities for NSP, micronutrients, and fruit and vegetables, for canteen, packed and street lunches, are indicated as percentages of those provided by a hypothetical meal exactly meeting the SNSSL requirements, in Figure 16.

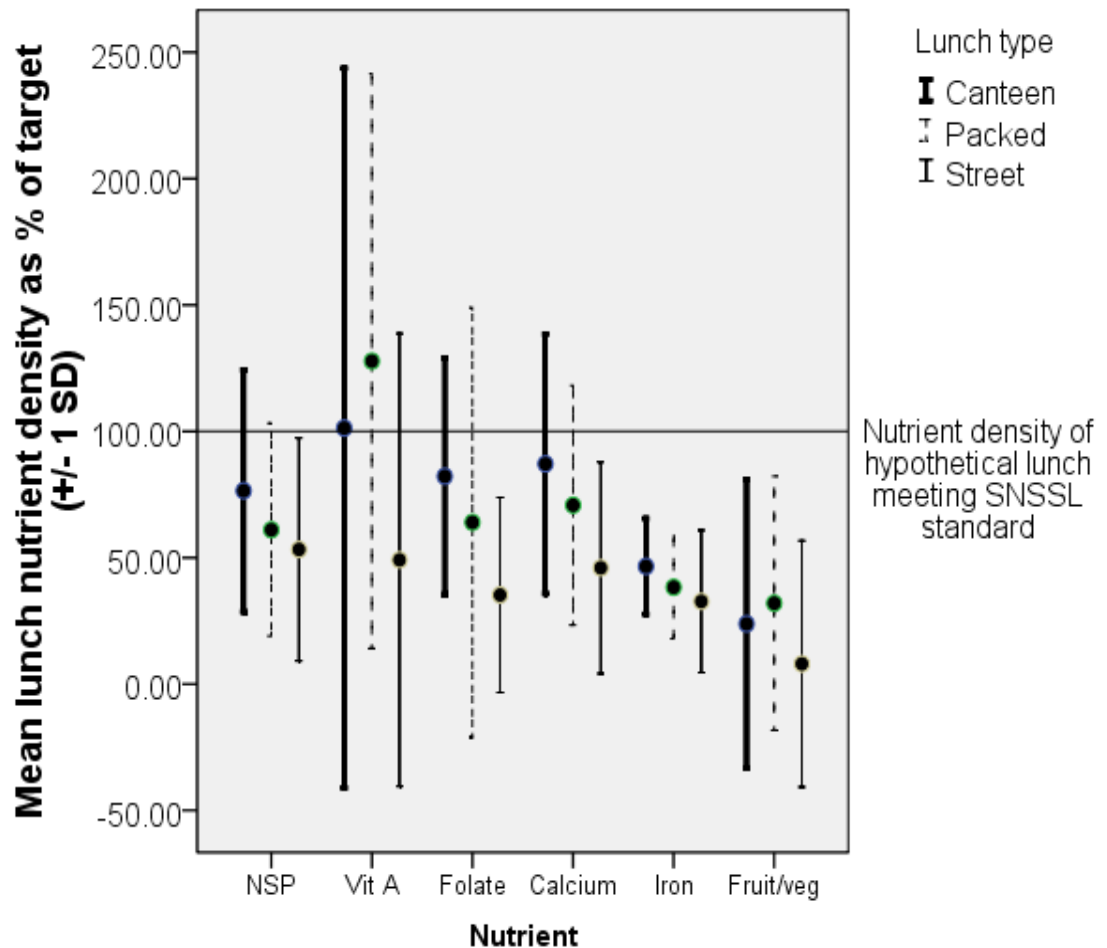


Figure 16: Mean nutrient density for canteen, packed and street lunches, as % of that provided by a lunch meeting the SNSSL requirements. NSP, vitamin A, folate, calcium, iron, and fruit and vegetables

3.3.2) Ranking of lunch types showing the most and least favourable nutrient density (whether that is high or low) for nutrients included in the SNSSL

Canteen lunches showed the most favourable density in the present study, for several nutrients. They showed the lowest nutrient density for fat and NMES; the highest nutrient density for NSP, folate, calcium and iron. Canteen lunches did not show the least favourable nutrient density for any nutrient.

Packed lunches showed the most favourable (highest) density for vitamin A, and exceeded the nutrient density provided by a lunch meeting the SNSSL for this nutrient. Packed lunches showed the least favourable (highest) nutrient density for fat and SFA.

Street lunches did not show the most favourable nutrient density for any nutrient. Street lunches showed the least favourable nutrient density for NMES, NSP, vitamin A, folate, calcium, iron, and fruit and vegetables. Street lunches did not meet the nutrient density provided by an 'ideal' lunch meeting the SNSSL for any nutrient.

3.3.3) Detection and location of significant differences between nutrient densities for canteen, packed and street lunches

One-way between-groups analysis of variance (ANOVA) and Post-hoc tests (Tukey's) were used to compare the nutrient densities of the three lunch types. P values indicating presence of significant difference between canteen, packed and street lunches are shown at the top left of the following figures.

For visual comparison, a horizontal line denotes the nutrient density of a hypothetical lunch precisely meeting the appropriate SNSSL standard for the nutrient (or fruit/vegetables). These figures do not show the P values for significant differences between lunchtime densities and the hypothetical targets – this information can be found in Table 19.

The most significant differences in nutrient density between canteen, packed and street lunches were found for folate and calcium. The nutrient density for canteen lunches was highly significantly different (favourably, whether that was higher or lower) from packed and street lunches for all nutrients ($p < 0.001$), with three exceptions. For vitamin A, the nutrient density for packed lunches was significantly higher than for canteen lunches ($p < 0.01$). The mean canteen lunch nutrient density for SFA was marginally greater than that found in packed lunches, and the mean canteen lunch density of fruit and vegetable portions was marginally greater than that found in packed lunches, but these differences failed to reach statistical significance.

Lunch nutrient density for fat

Canteen lunches had a lower nutrient density for fat (3.63g/100kcal) than street lunches (4.47g/100kcal) and packed lunches (4.53g/100kcal). One-way ANOVA was conducted to compare the mean nutrient density for fat, for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for fat in canteen lunches was significantly lower than that for packed and street lunches ($p < 0.001$).

Lunchtime fat density for the three lunch types is compared in Figure 17.

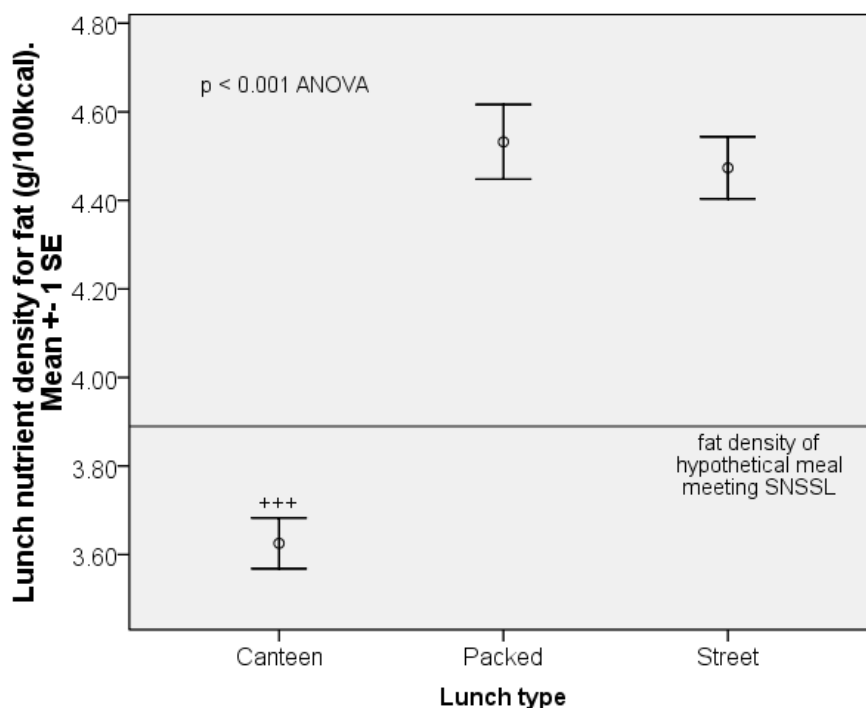


Figure 17. Lunchtime fat density for canteen, packed and street lunches. Fat density of a hypothetical meal meeting the SNSSL requirements (3.89g/100kcal) indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed

Canteen vs packed = +++ Canteen vs street = NS Packed vs street = NS

Lunch nutrient density for SFA

Street lunches had a higher SFA density (1.52g/100kcal) than canteen (1.54g/100kcal) and packed lunches (2.03g/100kcal). One-way ANOVA was conducted to compare the mean nutrient density for SFA, for the lunch types. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated a significantly lower mean nutrient density for SFA in canteen and street lunches than for packed lunches ($p < 0.001$). Mean nutrient density for street lunches was higher than for canteen lunches, but this difference failed to reach statistical significance.

Lunchtime SFA density for the three lunch types is compared in Figure 18.

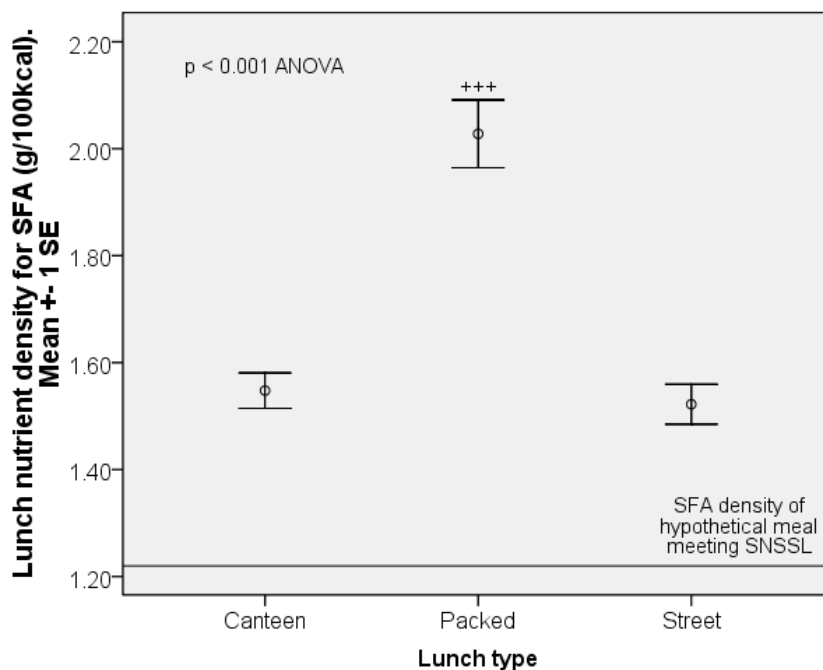


Figure 18: Lunchtime SFA density for canteen, packed and street lunches. SFA density of a hypothetical meal meeting the SNSSL requirements (1.22g/100kcal) indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of packed vs canteen and street

Canteen vs packed = +++ Canteen vs street = NS Packed vs street = +++

Lunch nutrient density for NMES

Canteen lunches had a lower NMES density (3.22g/100kcal) than packed (4.40g/100kcal) or street lunches (4.94g/100kcal). One-way ANOVA was conducted to compare the mean NMES density for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated a significantly lower mean nutrient density for NMES in canteen lunches ($p < 0.001$) than packed or street lunches. Mean nutrient density for NMES in packed lunches was lower than for street lunches (difference not statistically significant).

Lunchtime NMES density for the three lunch types is compared in Figure 19.



Figure 19. Lunchtime NMES density for canteen, packed and street lunches. NMES density (2.79g/100kcal) of a hypothetical meal meeting the SNSSL requirements indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = not signif

Lunch nutrient density for NSP

Canteen lunches had a higher NSP density (0.32g/100kcal) than packed (0.50g/100kcal) or street lunches (0.43g/100kcal). One-way ANOVA was conducted to compare mean NSP density for canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated a significantly lower mean nutrient density for NSP in canteen lunches ($p < 0.001$) than packed or street lunches. Mean nutrient density for NSP in packed lunches was lower than for street lunches (difference not statistically significant).

Lunchtime NSP density for the three lunch types is compared in Figure 20.

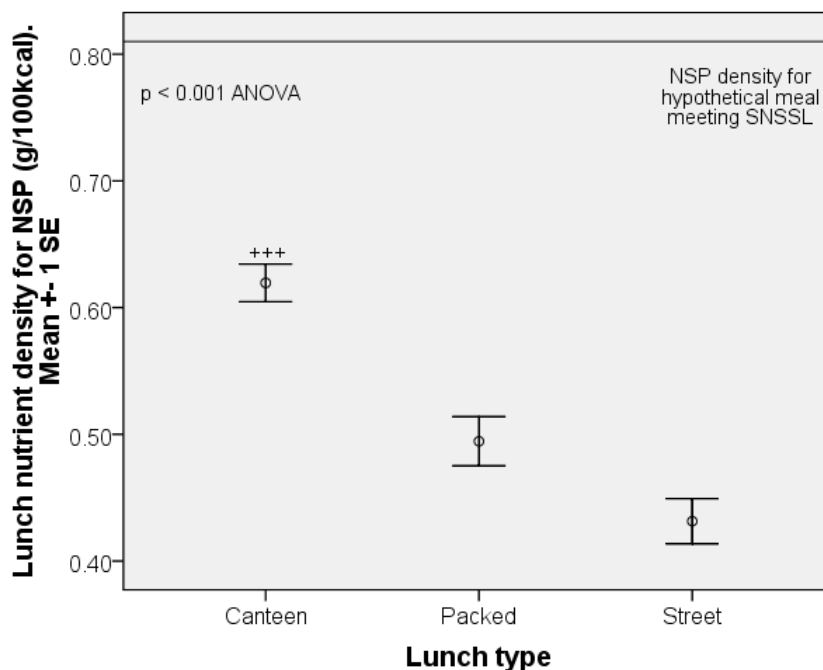


Figure 20. Lunchtime NSP density for canteen, packed and street lunches. NSP density (0.81g/100kcal) of a hypothetical meal meeting the SNSSL requirements indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = not signif

Lunch nutrient density for vitamin A

Packed lunches had a higher vitamin A density (36.63ug/100kcal) than canteen (29.01ug/100kcal) or street lunches (14.07ug/100kcal). One-way ANOVA was conducted to compare the mean nutrient density of vitamin A, in the lunch types. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated a significantly higher mean vitamin A density in packed lunches than canteen lunches ($p < 0.01$). In turn, the mean nutrient density for canteen lunches was significantly higher than that for street lunches ($p < 0.001$).

Lunchtime vitamin A density for the three lunch types is compared in Figure 21.

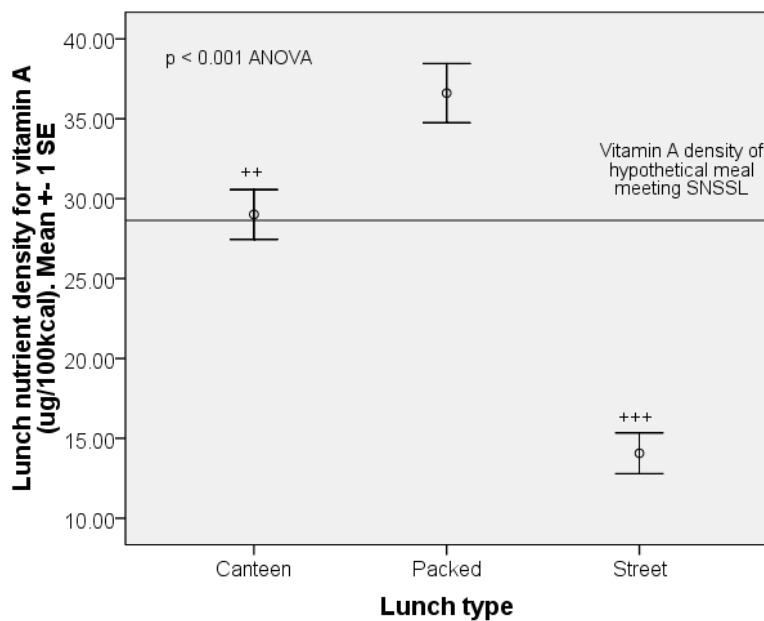


Figure 21. Lunchtime vitamin A density for canteen, packed and street lunches. Vitamin A density (28.64ug/100kcal) of a hypothetical meal meeting the SNSSL requirements indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of street vs packed and canteen

++ = $p < 0.01$ for comparison of canteen vs packed

Canteen vs packed = ++ Canteen vs street = +++ Packed vs street = +++

Lunch nutrient density for folate

Canteen lunches had a higher nutrient density for folate (10.18ug/100kcal) than packed lunches (7.93ug/100kcal) or street lunches (4.36ug/100kcal). One-way ANOVA was conducted to compare the mean nutrient density of folate, in canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for folate, for each of the lunch types – canteen, packed and street – was significantly different ($p < 0.001$).

Lunchtime folate density for the three lunch types is compared in Figure 22.

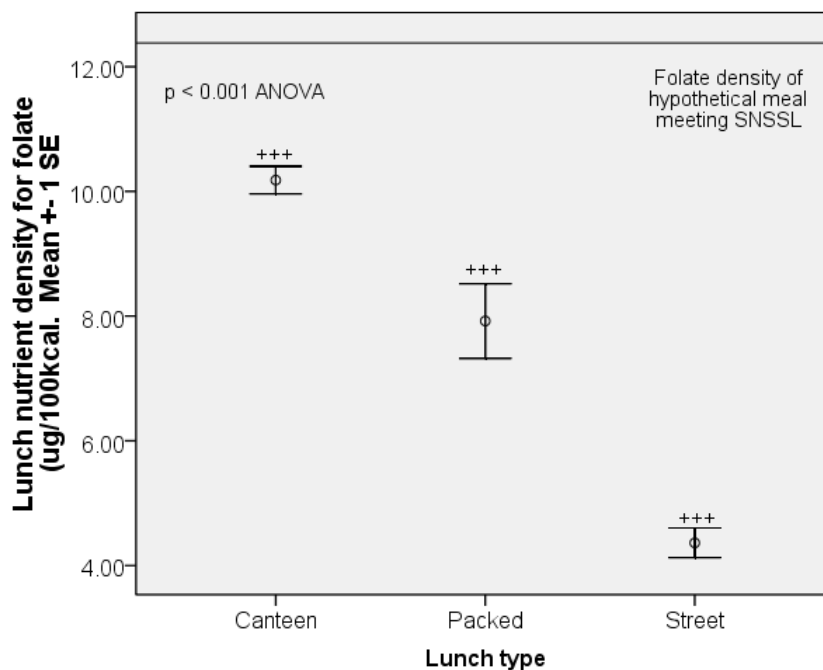


Figure 22. Lunchtime folate density for canteen, packed and street lunches. Folate density (12.38ug/100kcal) of a hypothetical meal meeting the SNSSL requirements indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street, and packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Lunch nutrient density for calcium

Canteen lunches had a higher nutrient density for calcium (47.22mg/100kcal) than packed (38.33mg/100kcal) or street lunches (24.92mg/100kcal). One-way ANOVA was conducted to compare the mean nutrient density of calcium, in canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for calcium, in each of the lunch types – canteen, packed and street – was significantly different ($p < 0.001$).

Lunchtime calcium density for the three lunch types is compared in Figure 23.

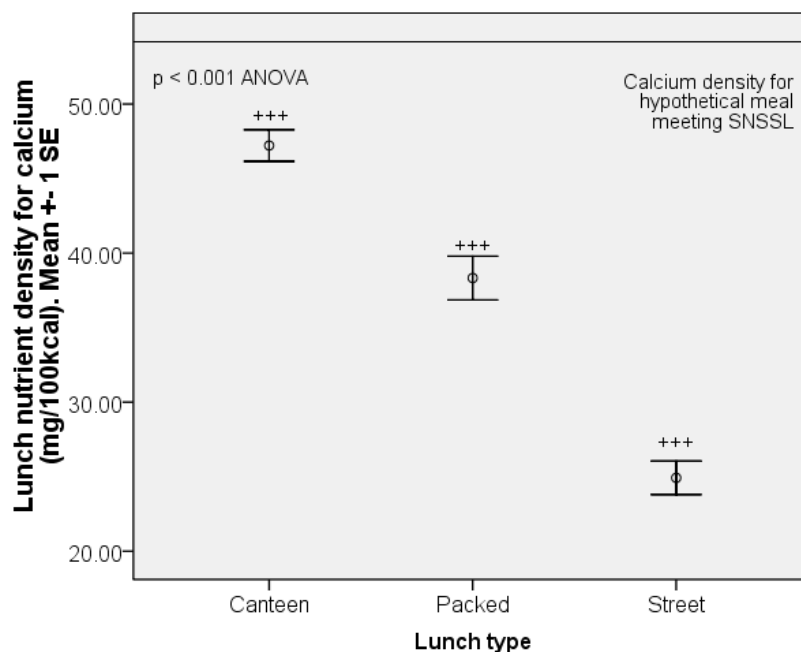


Figure 23. Lunchtime calcium density for canteen, packed and street lunches. Calcium density (54.18mg/100kcal) of a hypothetical meal meeting the SNSSL requirements indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street, and packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Lunch nutrient density for iron

Canteen lunches had a higher nutrient density for iron (0.42mg/100kcal) than packed lunches (0.35mg/100kcal) or street lunches (0.30mg/100kcal). One-way ANOVA was conducted to compare mean nutrient density of iron, in canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for iron in canteen lunches was significantly higher than that in packed lunches ($p < 0.001$). In turn, the mean nutrient density for canteen lunches was significantly higher than that for street lunches, but the significance was lower ($p < 0.01$).

Lunchtime iron density for the three lunch types is compared in Figure 24.

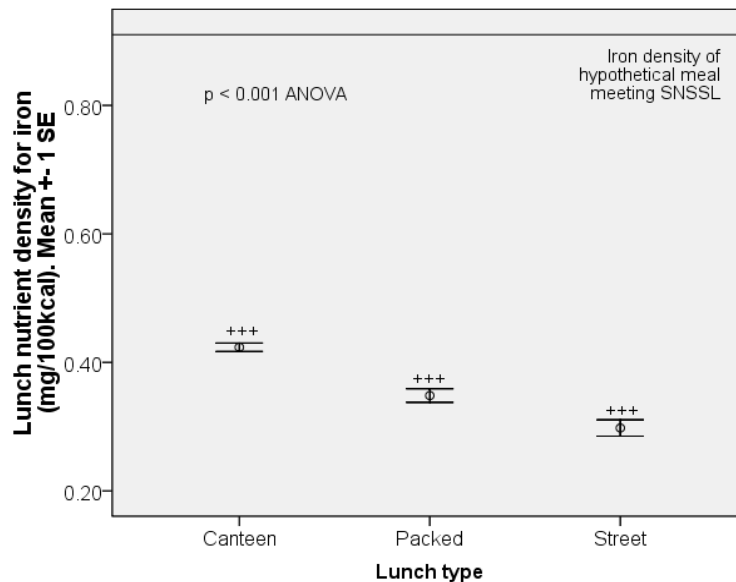


Figure 24. Lunchtime iron density for canteen, packed and street lunches. Iron density (0.01mg/100kcal) of a hypothetical meal meeting the SNSSL requirements indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street, and packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Lunch nutrient density for fruit and vegetables

Packed lunches had a higher fruit and vegetable density (0.10 portions/100kcal) than canteen (0.07 portions/100kcal) or street lunches (0.03 portions /100kcal). One-way (ANOVA) was conducted to compare the mean nutrient fruit and vegetable density, in canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean fruit and vegetable density in packed lunches (the highest fruit and vegetable density) was higher than that for canteen lunches, but this difference did not reach statistical significance. Mean fruit/vegetable density for street lunches (the lowest) was significantly lower than that for both canteen and packed lunches ($p < 0.001$).

Lunchtime fruit / vegetable density for the three lunch types is compared in Figure 25.

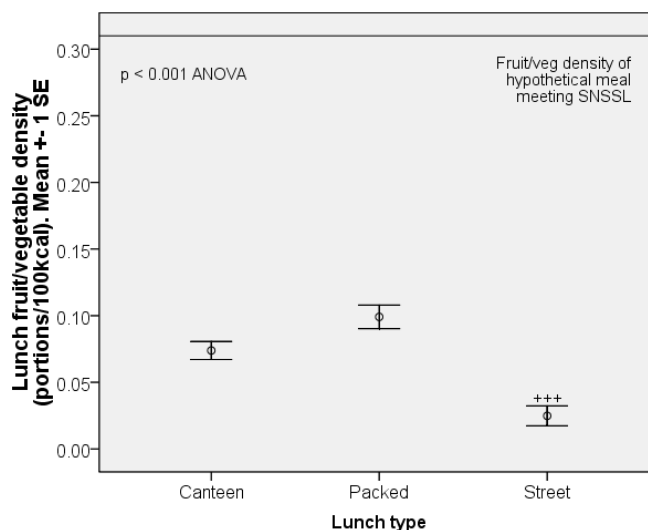


Figure 25. Lunchtime fruit and vegetable density for canteen, packed and street lunches. Fruit/vegetable density (0.31 portions/100kcal) of a hypothetical meal meeting the SNSSL requirements indicated for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunches

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of street vs canteen and packed

Canteen vs packed = NS Canteen vs street = +++ Packed vs street = +++

3.4) Analysis of total daily nutrient intake and density data – whole sample

Descriptive statistics were calculated for the whole sample.

Table 18: Total daily intake of energy, nutrients, and fruit and vegetables, for whole sample, mean and standard deviation. Nutrients considered = protein, total carbohydrate, fat, % energy from fat, SFA, % energy from SFA, NMES, % energy from NMES, vitamin C, vitamin A, folate, calcium, iron)

NUTRIENT	MEAN	SD
Energy (kcal)	1988	584
Protein (g)	67.9	22.9
Total carbohydrate (g)	275.1	106.7
Fat (g)	82.6	31.2
% Energy from fat	37.0	7.3
SFA (g)	32.3	13.8
% Energy from SFA	14.6	4.5
NMES (g)	79.3	44.8
% Energy from NMES	15.7	7.1
NSP (g)	10.9	4.5
Vitamin C (mg)	75.6	65.1
Vitamin A (ug)	523	375
Folate (ug)	186	81
Calcium (mg)	857	407
Iron (mg)	9.7	3.7
Fruit/vegetables (portions)	1.3	1.3

Table 18 (and also Table 21) include intakes of protein, total carbohydrate, and vitamin C, which were not included in the more detailed analyses included in the present study (for justification, see section 2.7). Tables 18 and 21 confirm that intakes of protein and vitamin C are not of major concern in this population (however, mean total CHO intake for days including a packed lunch did fall marginally below the DRV, see Table 21).

Mean vitamin C intake was more than twice the RNI for the population (for days including all lunch types), despite the children's notably low fruit and vegetable intake. The NDNS for children (Gregory & Lowe 2000) indicates that potato products and drinks (foods not classified as fruit and vegetables in the Government recommendations (Department of Health 2003a), nor the present study) make a significant contribution to children's vitamin C intake, with fruit juice and soft drinks contributing 46.5% towards total vitamin C intake in 11 – 14-year-old children's in this age group, and potatoes contributing over 20% towards vitamin C intake for this age group. Although the nature of foods consumed was not analysed in the present study, it was noted by the researcher that potato products were popular food choices among the study population. In the present study, only one portion of fruit juice was counted towards fruit and vegetable intake (regardless of whether more juice was consumed), in common with the Government recommendations for fruit and vegetables (Department of Health 2003a), in which only one portion can be counted towards the daily fruit and vegetable target. Therefore it is feasible that the present study could find adequate vitamin C intakes, despite also finding extremely low intakes of fruit and vegetables, since children were also obtaining vitamin C from other sources including potatoes and drinks.

3.4.1) Comparison of total daily nutrient intake with dietary reference values

Dietary Reference Values or DRVs (Department of Health 1991) are working estimates of amounts of energy and nutrients required by different groups of the population, such as children of different ages, adults, and the elderly. They replace the Recommended Daily Amounts (RDAs) published in 1979 (Department of Health and Social Security 1979).

DRVs include:

Estimated Average Requirement (EAR): This is the estimated mean requirement of a population. The EAR is commonly used as a target for energy intake.

Reference Nutrient Intake (RNI): A value set at two standard deviations above the EAR. Nutrient intakes exceeding the RNI are expected to supply the requirements of 97.5% of the population for which the RNI was defined. They are not minimum targets, but individuals reaching the RNI are likely to be consuming sufficient of a particular nutrient.

Lower Reference Nutrient Intake (LRNI): A value set at two standard deviations below the EAR. Nutrient intakes below the LRNI are expected to supply the needs of only 2.5% of the population, the individuals with particularly low requirements. Individuals with intakes below the LRNI are likely to be consuming sufficient of a particular nutrient.

For some nutrients, the DRV differs for males and females. For the purposes of this study, the DRV (EAR, RNI, and LRNI where applicable) was averaged to provide a mean target for males and females of the age range in the present study (11 – 14 years). This was considered appropriate, because the number of males and females in the sample were very similar. Whole day nutrient intake of the sample as a percentage of this 'average DRV for males/females' was calculated for each nutrient, and for the daily target of five portions of fruit and vegetables. From now on in this section, when study data is compared with the 'DRV', it is compared with this mean value for males and females.

For reference, for energy the EAR for 11 – 14-year-olds (the age range in the present study) is 2,220 and 1,845 kcal for boys and girls respectively. For fat, the DRV is no more than 35% of dietary energy, equating to 85.5g and 71.8g for boys and girls respectively. The DRV for SFA is a maximum of 10% of dietary energy, or 24.4g for boys and 20.5g for girls. A maximum of 10% of dietary energy is the DRV for NMES, equating to 55.0g for boys and 46.1g for girls. The RNI for calcium is 1000mg and 800mg for boys and girls respectively, and 11.3mg and 14.8mg for iron. No DRV has been set for NSP for children, and this study utilized the adult DRV of 18g per day. Recommendations for vitamin A, folate and fruit and vegetables do not differ for males and females of the relevant age.

Table 19: Total daily nutrient mean intake of sample as percentage of EAR, RNI, and LRNI (where applicable). Standard deviation (SD) in brackets

NUTRIENT	EAR/DRV/RNI *	LRNI *	Intake as % of DRV (SD)	Intake as % of LRNI (SD)
Energy (kcal)	2,033	n/a	97.8% (28.7)	n/a
Fat (g)	78.7	n/a	104.5% (39.5)	n/a
SFA (g)	22.5	n/a	129.6% (55.6)	n/a
NMES (g)	50.6	n/a	141.8% (80.1)	n/a
NSP (g)	18	12	60.3% (24.9)	90.5% (37.3)
Vitamin A (ug)	600	250	87.1% (62.5)	209.1% (150.0)
Folate (ug)	200	100	92.9% (40.8)	185.7% (81.7)
Calcium (mg)	900	465	95.3% (45.3)	184.4% (87.6)
Iron (mg)	13.1	7.1	73.7% (28.1)	136.1% (51.9)
Fruit/veg (portions)	5	n/a	26.7% (26.5)	n/a

Figures in g in EAR/RNI column for fat, SFA and NMES are derived from DRVs.

* These values represent the mean of the EAR, RNI and LRNI for males and females aged 11 – 14 years.

Figure 26 shows the extent to which nutrient intakes for the whole sample exceed or fall short of Dietary Reference Values.

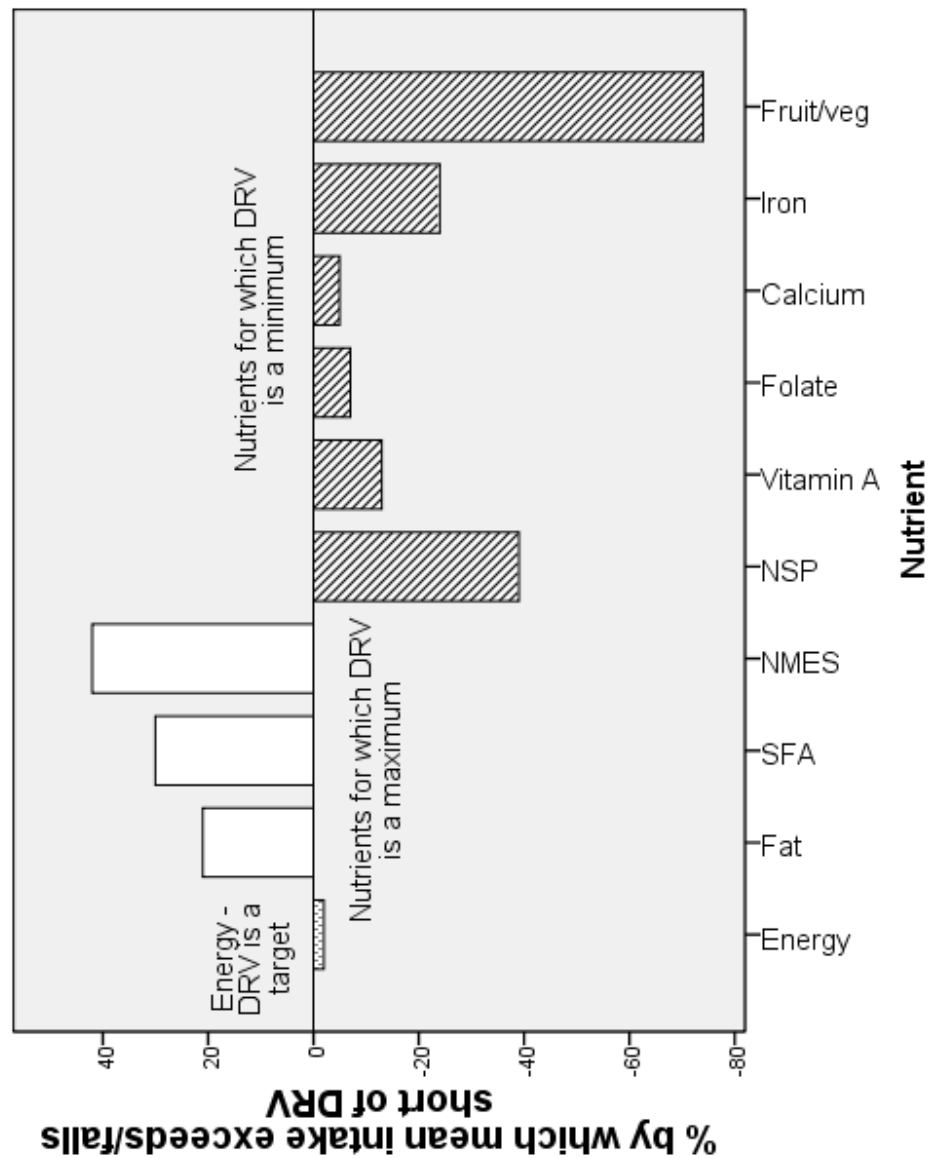


Figure 26: Extent to which nutrient intakes for the whole sample exceed or fall short of Dietary Reference Values

It is notable that for the nutrients with a DRV that is a maximum value, the sample mean daily intake exceeded the DRV. For nutrients where the DRV is a minimum value, along with fruit and vegetables (for which the Government target is also a minimum), the sample mean daily intake fell short of the target. In the case of energy, the guideline is an Estimated Average Requirement (EAR) for the population, and the mean intake for the sample was very close to (slightly lower) than the recommendation.

3.4.2) Percentage of whole sample meeting or failing to meet the DRV (EAR / RNI / LRNI)

To determine the percentage of children who met the dietary reference values and Government target for fruit and vegetables, new variables were created, coded '0' for a day failing to meet a particular DRV or target and '1' for lunches meeting it.

Figure 27 shows the percentage of the sample meeting the DRV for energy, fat, SFA, NMES, NSP, vitamin A, folate, calcium, iron, and the Government recommendation of 5 portions of fruit and vegetables per day.

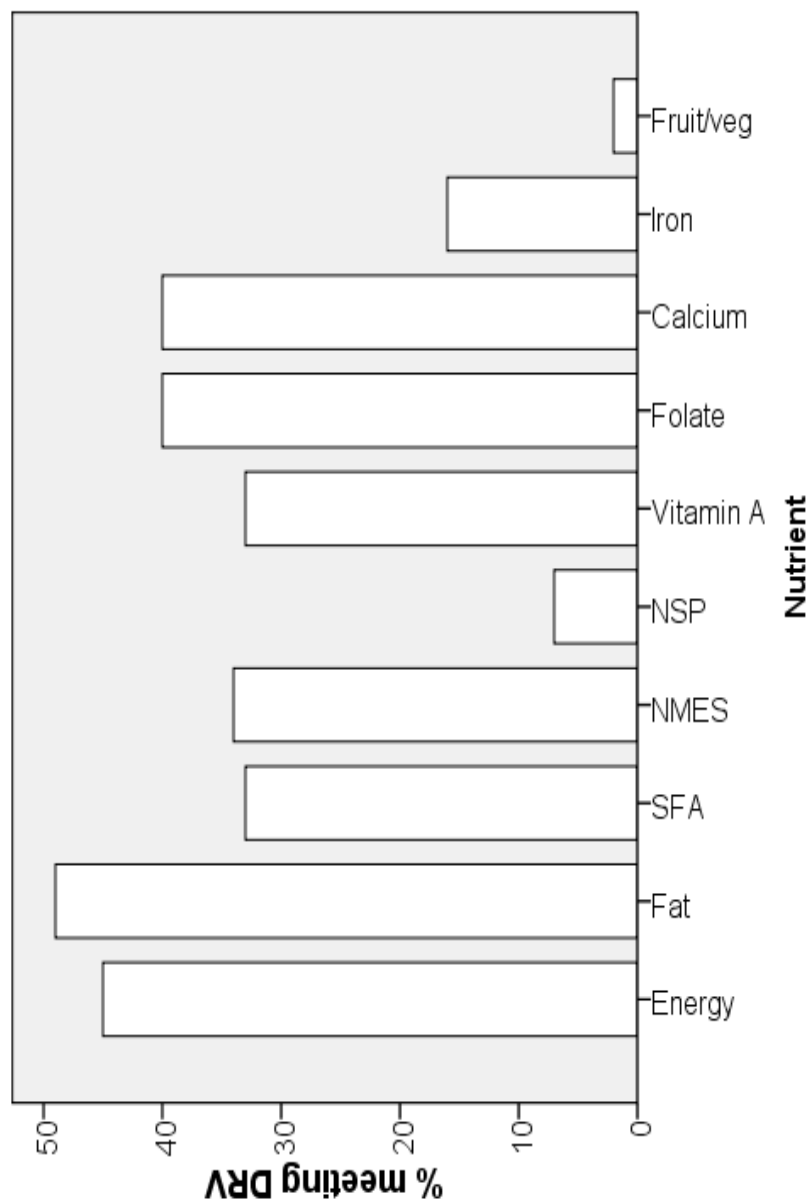


Figure 27: Percentage of whole sample meeting the DRV for energy, fat, SFA, NMES, NSP, Vitamin A, Folate, Calcium, Iron, and the Government recommendation for fruit and vegetables

3.5) Total daily nutrient density – whole sample

Mean nutrient density for each day's intake for the nutrients analysed (plus fruit and vegetables) was calculated by dividing intake by energy content (kcal). To make the results of the analysis easier to interpret, nutrient densities were expressed per 100kcal.

The EAR for energy (averaged for boys and girls aged 11 – 14 years) is for a daily energy intake of 2,033kcal. In the present study, the mean energy intake for the whole sample was 1,988kcal

The nutrient densities from the present study were compared with those for a hypothetical day's intake, which precisely met the DRV for the nutrients considered, and the Government target of five portions of fruit and vegetables per day. The statistical test used was the one-sample t-test.

Table 20: Nutrient densities over whole day for present study (whole sample) compared with nutrient density for a hypothetical day meeting the DRVs for the nutrients considered. Presence and nature of significant difference. Standard deviation (SD) in brackets

Nutrient	Nutrient density		P value
	Hypothetical day meeting DRV	Present study: whole sample (SD)	
Fat (g/100kcal)	3.89	4.11 (0.81)	p < 0.001
SFA (g/100kcal)	1.22	1.62 (0.49)	p < 0.001
NMES (g/100kcal)	2.75	3.97 (3.42)	p < 0.001
NSP (g/100kcal)	0.89	0.56 (0.21)	p < 0.001
Vitamin A (ug/100kcal)	26.09	26.37 (36.19)	NS
Folate (ug/100kcal)	9.84	8.00 (7.32)	p < 0.001
Calcium (mg/100kcal)	44.27	38.81 (27.61)	p < 0.001
Iron (mg/100kcal)	0.64	0.37 (0.21)	p < 0.001
Fruit/veg (portions/100g)	0.25	0.07 (0.08)	p < 0.001

NS indicates not significant

The density of fat and SFA for the sample exceeded that of a hypothetical day that met the RNI. For NSP, folate, calcium, and fruit and vegetables, the nutrient density in the present study was lower than that for a hypothetical day meeting the DRV (or the recommendation for fruit and vegetables). These differences indicated that the nutrient densities for the sample were less conducive to a healthy diet than those for the hypothetical day meeting the DRVs and fruit and vegetable recommendation.

Figure 28 shows the nutrient density of whole sample as percentage of that provided by a hypothetical day providing the DRV for the nutrients considered in the present study.

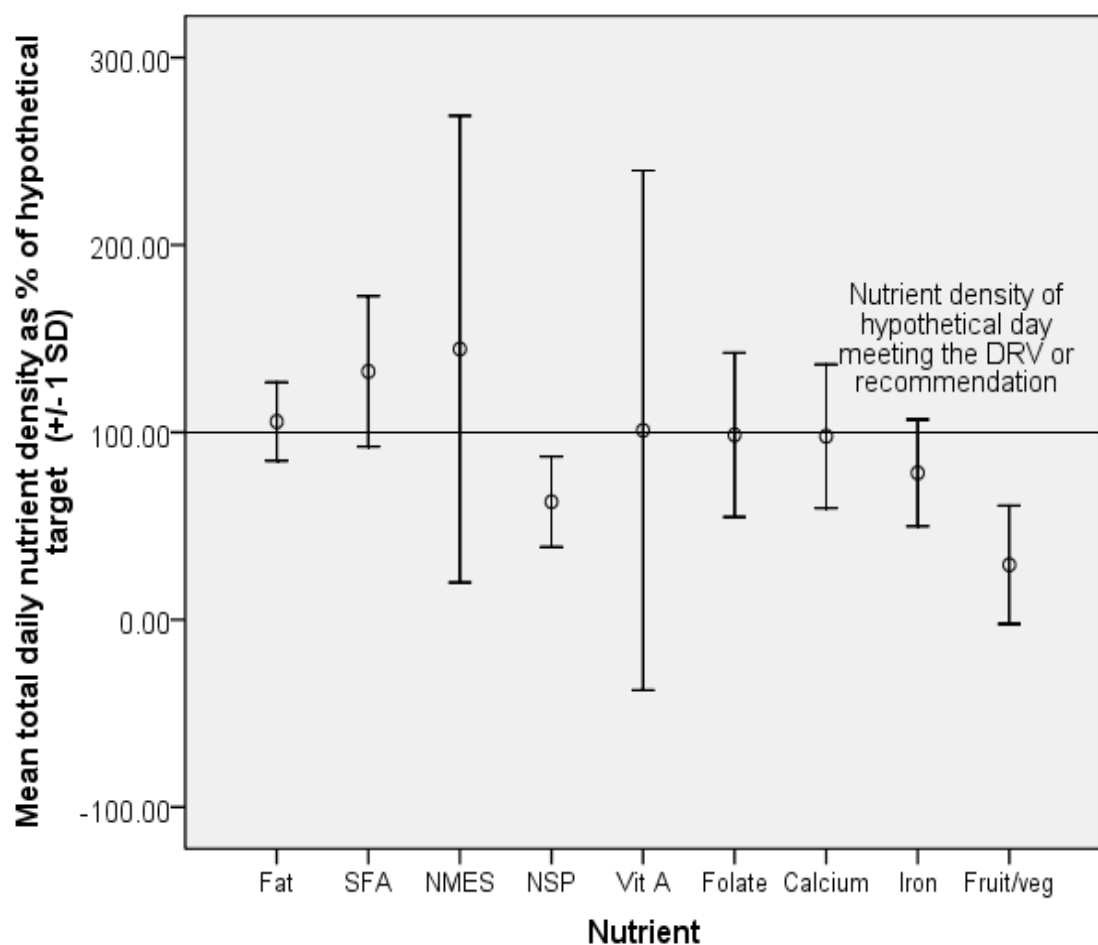


Figure 28: Mean nutrient density of whole sample as percentage of that provided by a hypothetical day providing the DRV for fat, SFA, NMES, NSP, Vitamin A, folate, calcium, iron, and the Government recommendation for fruit and vegetables

3.6) Analysis of total daily intake data - split by lunch type

For the following analyses, the sample was split according to which lunch type (canteen, packed or street) a day's data included. These are described in future as canteen lunch days, packed lunch days and street lunch days.

3.6.1) Comparison of mean total daily intake data for canteen, packed and street lunch days, with DRVs

Descriptive statistics were calculated for intake data on canteen, packed and street lunch days. One sample T-tests were used to compare total daily nutrient intakes for days including each lunch type, with the appropriate DRVs, to determine whether there was a significant difference between the actual intake and the DRV. In all of the comparisons (see Table 20) the difference was highly significant ($p < 0.001$).

Table 21: Total daily intake for energy, nutrients, fruit/veg, mean and standard deviation, for canteen, packed and street lunches, compared with appropriate DRVs, and fruit and vegetable recommendation. Standard deviation in brackets. (Nutrients considered = protein, total carbohydrate, fat, % energy from fat, SFA, % energy from SFA, NMES, % energy from NMES, Vitamin C, vitamin A, folate, calcium, iron)

NUTRIENT	EAR, DRV, RNI or recommendation *	CANTEEN	PACKED	STREET
Energy (kcal)	2,033	1,877 (593)	1,990 (521)	2,174 (569)
Protein (g)	41.7	68.7 (23.9)	66.1 (20.6)	67.8 (22.8)
Total carbohydrate (g)	254.1	276.5 (119.4)	252.1 (77.2)	290.1 (100.5)
Fat (g)	79.0	74.5 (29.7)	85.8 (31.3)	93.9 (29.5)
% energy from fat	35.0	35.5 (7.5)	38.1 (7.4)	38.7 (6.5)
SFA (g)	24.9	29.8 (13.4)	34.1 (14.3)	35.0 (13.6)
% energy from SFA	11.0	14.3 (4.5)	15.3 (4.9)	14.4 (4.0)
NMES (g)	55.9	69.9 (41.2)	82.1 (42.8)	93.1 (48.1)
% energy from NMES	11.0	14.6 (6.7)	16.5 (7.3)	16.9 (7.4)
NSP (g)	18.0	10.9 (4.5)	11.1 (4.5)	10.7 (4.4)
Vitamin C (mg)	35.0	76.4 (69.8)	89.0 (70.0)	64.9 (53.6)
Vitamin A (ug)	600	513 (369)	592 (398)	486 (361)
Folate (ug)	200	193 (81)	188 (87)	172 (78)
Calcium (mg)	900	879 (410)	857 (404)	820 (401)
Iron (mg)	13.1	9.6 (3.8)	9.8 (3.6)	9.6 (3.5)
Fruit/veg (portions)	5.0	1.4 (1.3)	1.8 (1.6)	1.0 (0.9)

(* EAR for energy, DRV for fat, SFA, NMES and NSP (g fat, SFA, NMES derived from DRV), RNI for vitamin C, vitamin A, folate, calcium and iron, Government recommendation for fruit/vegetables. Figures averaged for males and females aged 11 – 14 years, except for NSP, for which there is no DRV for children and the adult figure is used).

DRVs met:

Canteen

The mean intake for fat, for days including a canteen lunch, was significantly below the RNI ($p < 0.001$).

Packed

The mean energy intake for days including a packed lunch was significantly below the EAR ($p < 0.001$).

DRVs not met:

Canteen:

The mean intakes for canteen lunch days were significantly below the RNI for NSP, vitamin A, folate, iron, and the Government target for fruit and vegetable portions ($p < 0.001$).

The mean intakes for canteen lunch days were significantly above the RNI for SFA and NMES ($p < 0.001$).

Packed:

The mean intakes for packed lunch days were significantly above the RNI for fat, SFA and NMES.

The mean intakes for packed lunch days were significantly below the RNI for NSP, vitamin A, folate, calcium and iron ($p < 0.001$).

Street:

The mean intakes for street lunch days were significantly above the EAR for energy, and the RNI for fat, SFA and NMES.

The mean intakes for street lunch days were significantly below the RNI for NSP, vitamin A, folate, calcium and iron ($p < 0.001$).

The mean intakes of days including all lunch types were below the Government target for fruit and vegetable portions ($p < 0.01$).

The mean intakes for energy, and nutrients for which the DRV is a maximum value, expressed as a percentage of the EAR or DRV, can be seen in Figure 29.

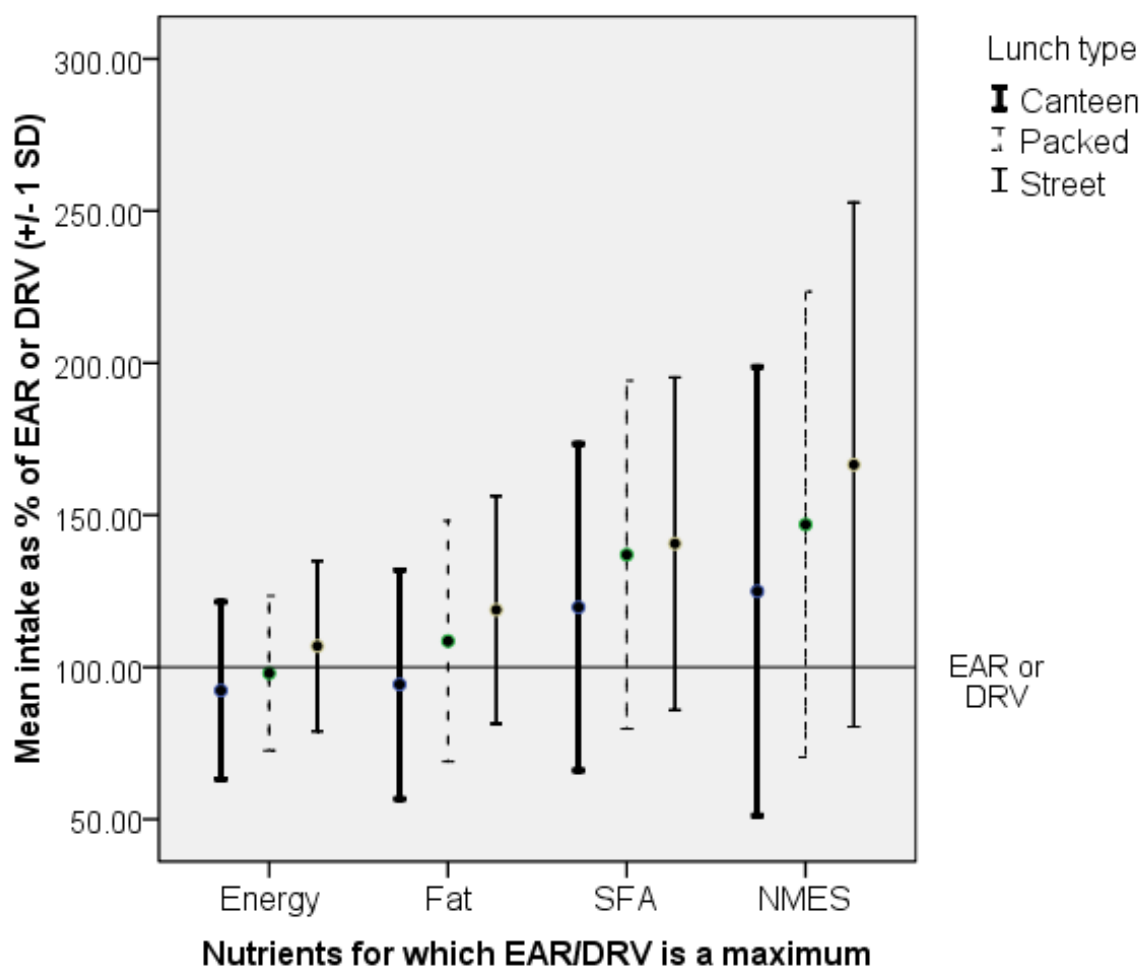


Figure 29: Mean daily intake for canteen, packed and street lunch days, as percentage of DRV: Energy, and nutrients for which DRV is a maximum value (fat, SFA and NMES)

The mean daily intake for nutrients/foods for which the DRV/recommendation is a minimum value can be seen in Figure 30 (following page).

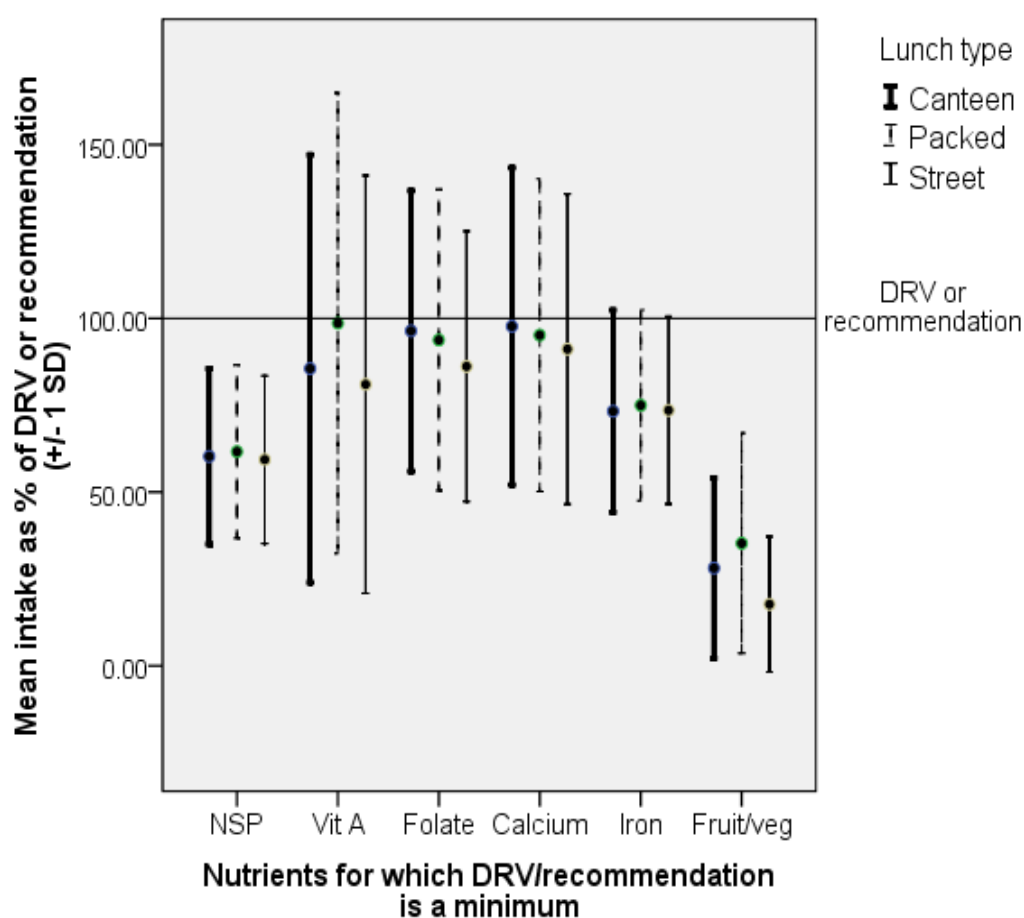


Figure 30: Mean daily intake for canteen, packed and street lunch days, as percentage of DRV: Nutrients/foods for which the DRV/recommendation is a minimum value (NSP, vitamin A, folate, calcium, iron, fruit/vegetables)

More detailed figures for each nutrient plus fruit and vegetables, showing p values (ANOVA), and standard error of mean for each lunch type, can be found later in this section (Figures 31 – 40).

3.6.2) Ranking of nutrient intake for canteen, packed and street lunches

Days including canteen, packed and street lunches were ranked to show the most and least favourable nutrient intake (whether that was high or low) for nutrients included in the SNSSL. Energy was not included in this ranking, to avoid suggesting that the highest or lowest possible energy intake was desirable.

Canteen lunch days showed the most favourable daily intake for fat, SFA, NMES, folate and calcium. They did not show the least favourable daily intake for any nutrient.

Packed lunch days showed the most favourable daily intake for NSP, vitamin A, iron, and fruit and vegetables. They did not show the least favourable daily intake for any nutrient.

Street lunch days did not show the most favourable daily intake for any nutrient. They showed the least favourable total daily intake for all nutrients.

3.6.3) *Detection and location of significant differences between nutrient intakes for canteen, packed and street lunch days*

One-way between-groups ANOVA and Post-hoc tests (Tukey's tests) were used to compare the nutrient intake for canteen lunch days, packed lunch days and street lunch days. P values indicating presence of significant difference between days including the three lunch types are shown at the top left of the following figures. For visual comparison, a horizontal line denotes the DRV (or recommendation for fruit/vegetables). For the P values for significant differences between total daily intakes and the DRV/recommendation, see section 3.6.1.

Whole day energy intake

Canteen lunch days had the lowest mean energy intake (1,877kcal), followed by packed lunch days (1,990kcal), with street lunch days having the highest energy intake (2,174kcal). One-way between-groups analysis of variance was conducted to compare the mean energy intake of canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean energy intake for canteen and packed lunch days was significantly lower than that of street lunch days (the highest value) $p < 0.001$. The mean energy intake for canteen lunch days was also significantly lower than that for packed ($p < 0.05$).

Daily energy intake for canteen, packed and street lunch days is compared in Figure 31.

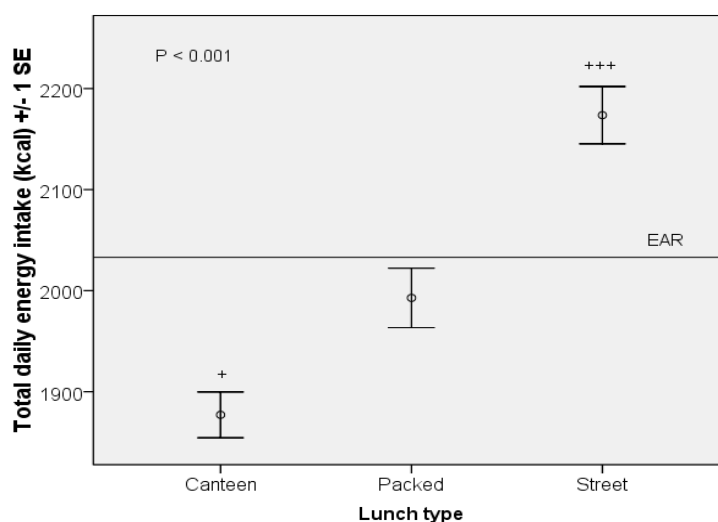


Figure 31: Daily energy intake (kcal), for canteen, packed and street lunches. Standard Error of Mean. EAR (2,033kcal) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+ = $p < 0.05$ for comparison of canteen vs packed

+++ = $p < 0.001$ for comparison of street vs packed and canteen

Canteen vs packed = + Canteen vs street = +++ Packed vs street = +++

Whole day fat intake

Canteen lunch days had the lowest mean fat intake (74.3g), followed by packed lunch days (85.8g), with street lunch days having the highest (93.9g). One-way between-groups ANOVA was conducted to compare the mean fat intake (g) for canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean fat intake for canteen lunch days (lowest intake) was significantly lower than that for the other lunch groups ($p < 0.001$). The fat intake for packed lunch days was significantly lower than that for street lunch days ($p < 0.01$).

Daily fat intake for canteen, packed and street lunch days is compared in Figure 32.

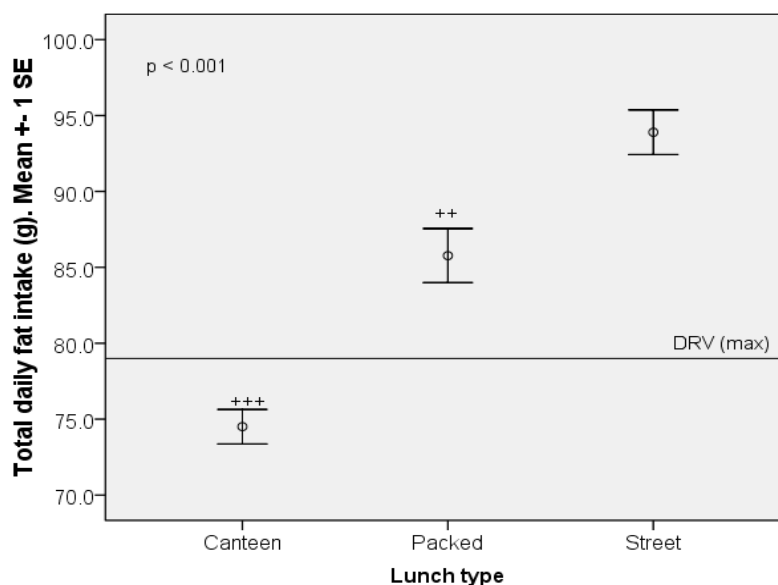


Figure 32: Daily fat intake (g), for canteen, packed and street lunch days. Standard Error of Mean. RNI (79g) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

++ = $p < 0.01$ for comparison of packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = ++

Whole day SFA intake

Canteen lunch days had the lowest mean SFA intake (29.8g), followed by packed lunch days (34.1g), with street lunch days having the highest (35.0g) intake. One-way between-groups ANOVA was conducted to compare mean SFA (g) intake for canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean fat intake for canteen lunch days (lowest intake) was significantly lower than that for the other lunch groups ($p < 0.001$). However, the difference in mean SFA intake for packed and street lunch days did not reach statistical significance.

Daily SFA intake for canteen, packed and street lunch days is compared in Figure 33.

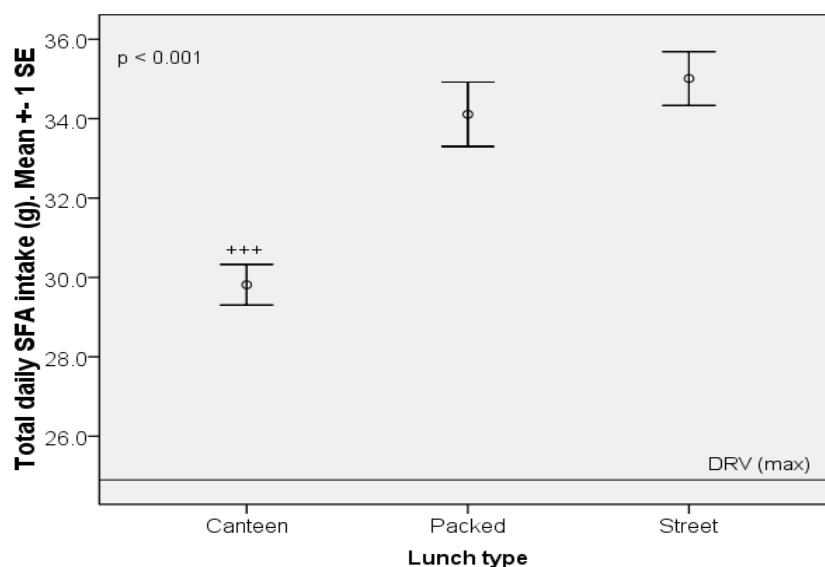


Figure 33: Comparison of daily SFA intake (g), for canteen, packed and street lunches.

Standard Error of Mean. RNI (24.9g) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

Difference between packed and street was not statistically significant

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = not signif

Whole day NMES intake

Canteen lunch days had the lowest mean NMES intake (69.9g), followed by packed lunch days (82.1g), with street lunch days having the highest (93.1g). One-way between-groups ANOVA was conducted to compare the mean NMES intake (g) for days including canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean NMES intake for canteen lunch days (lowest intake) was significantly lower than that for the other lunch groups, $p < 0.001$. For the difference in the mean NMES intake between packed and street lunch days, $p < 0.05$.

Daily NMES intake for canteen, packed and street lunch days is compared in Figure 34.

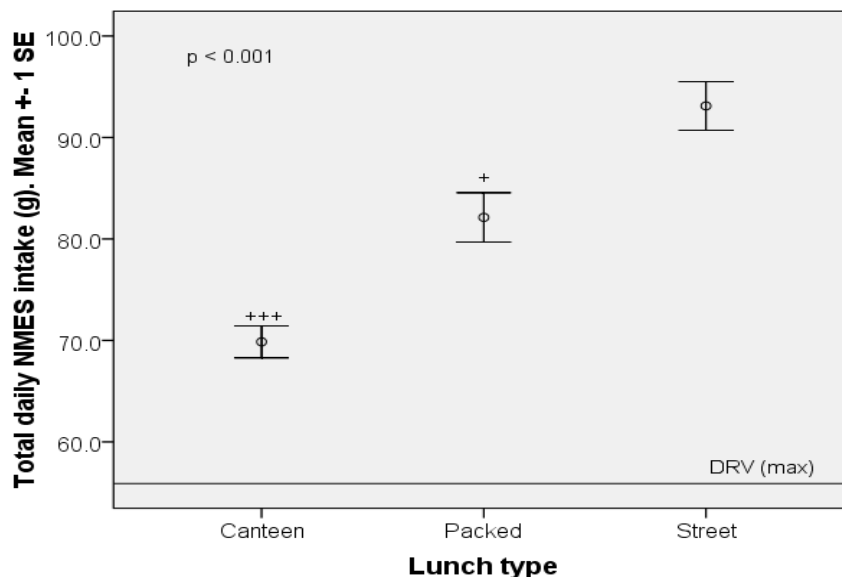


Figure 34: Daily NMES intake (g), for canteen, packed and street lunches. Standard Error of Mean. RNI (55.9g) also shown for comparison. Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street

+ = $P < 0.05$ for comparison of packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +

Whole day NSP intake

Packed lunch days had the highest mean NSP intake (11.1g), followed by canteen lunch days (10.9g), with street lunch days having the lowest (10.7g). One-way between-groups ANOVA was conducted to compare the mean NSP intake (g) for days including canteen, packed and street lunches. There was no statistically significant difference between the groups. Post-hoc comparisons (Tukey's test) indicated no significant differences in the mean NSP intake for canteen, packed and street lunch days.

Daily NSP intake for canteen, packed and street lunch days is compared in Figure 35.

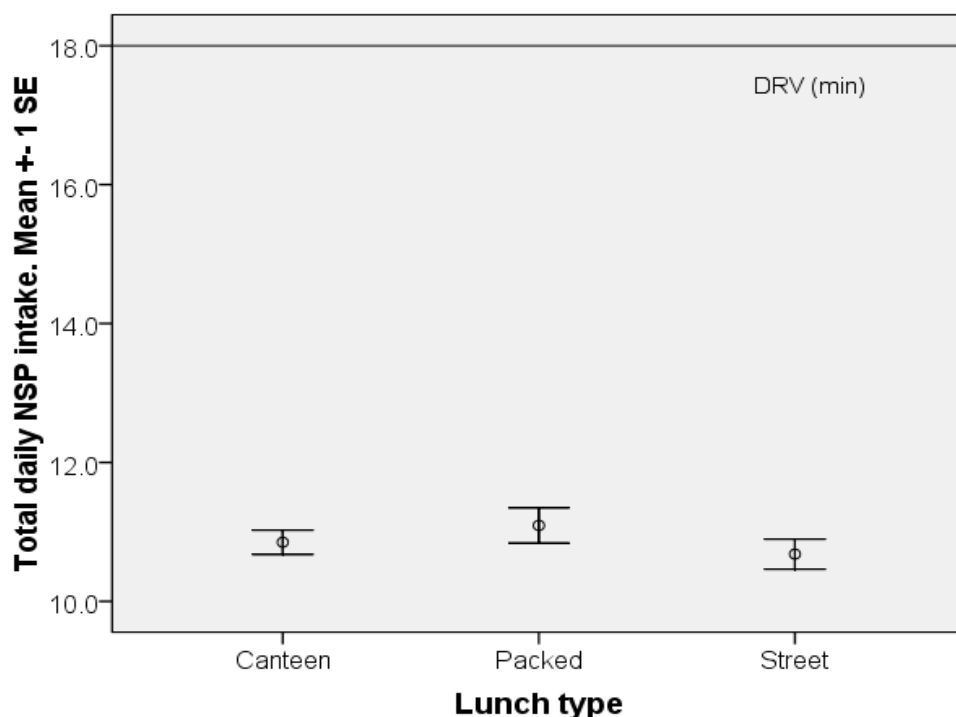


Figure 35: Daily NSP intake (g), for canteen, packed and street lunches. Standard Error of Mean. RNI (18g) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

No significant difference was detected between the NSP intakes for canteen, packed and street lunch days

Whole day vitamin A intake

Packed lunch days had the highest mean vitamin A intake (592ug), followed by canteen lunch days (513ug), with street lunch days having the lowest (486ug). One-way between-groups ANOVA was conducted to compare mean vitamin A intake (ug) for days including canteen, packed and street lunches. A statistically significant difference was detected ($p < 0.01$). This p value was less than that found for the equivalent comparison for energy, fat, SFA, NMES, folate and fruit and vegetables. Post-hoc comparisons (Tukey's test) indicated that the mean vitamin A intake for packed lunch days (highest intake) was significantly higher than for canteen or street days ($p < 0.01$). The difference between canteen and street lunch days did not reach statistical significance.

Daily vitamin A intake for canteen, packed and street lunch days is compared in Figure 36.

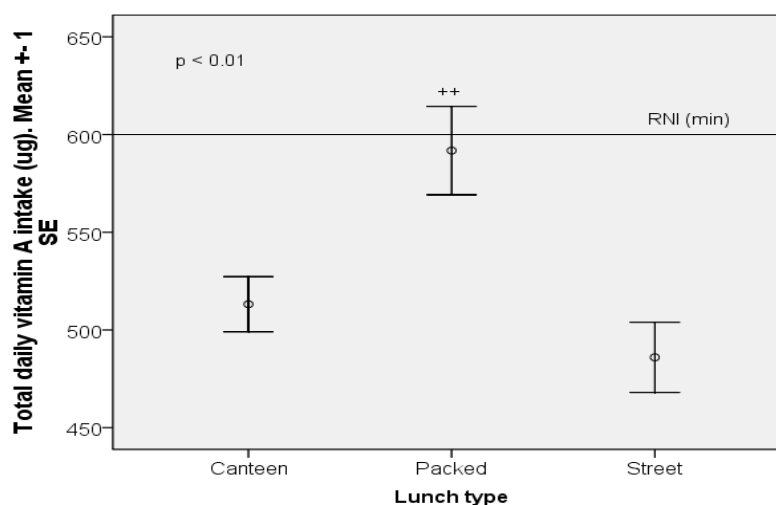


Figure 36: Daily vitamin A intake (ug), for canteen, packed and street lunch days. Standard Error of Mean. RNI (600ug) also shown for comparison
Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

++ = $p < 0.01$ for comparison of packed vs canteen and street

Canteen vs packed = ++ Canteen vs street = NS Packed vs street = ++

Whole day folate intake

Canteen lunch days lunches had the highest mean folate intake (193ug), followed by packed lunch days (188ug), with street lunch days having the lowest (172ug). One-way between-groups ANOVA was conducted to compare mean folate (ug) intake for canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean folate intake for canteen lunch days (highest intake) was significantly higher than that for street lunch days (lowest intake), $p < 0.001$. Intake for packed lunch days (intermediate intake) was significantly higher than that for street lunch days, $p < 0.05$. The difference in daily folate intake between packed and canteen lunch days did not reach statistical significance.

Daily folate intake for canteen, packed and street lunch days is compared in Figure 37.

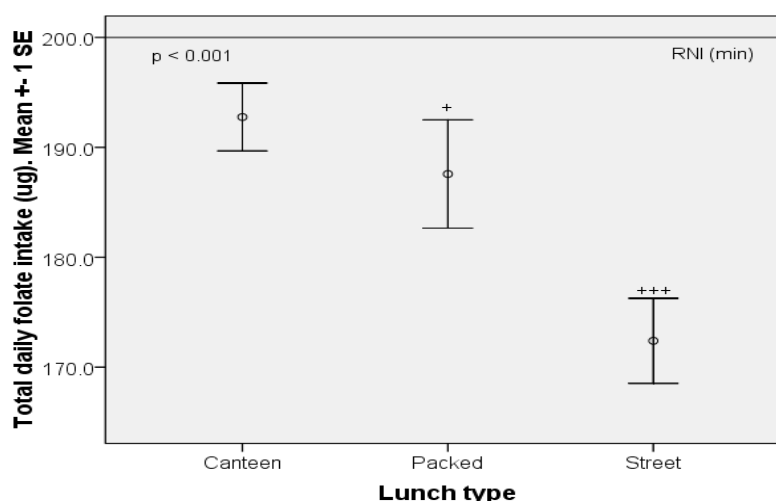


Figure 37: Comparison of daily folate intake (ug), for canteen, packed and street lunches. Standard Error of Mean. RNI (200ug) also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of street vs canteen

+ = $p < 0.05$ for comparison of street vs packed

Canteen vs packed = NS Canteen vs street = +++ Packed vs street = +

Whole day calcium intake

Days including canteen lunches had the highest mean calcium intake (879mg), followed by packed lunch days (857mg), with street lunch days having the lowest (820mg). One-way between-groups ANOVA was conducted to compare mean calcium intake (mg) for days including canteen, packed and street lunches. There was no statistically significant difference between the daily calcium intake of the three groups.

Daily calcium intake for canteen, packed and street lunch days is compared in Figure 38.

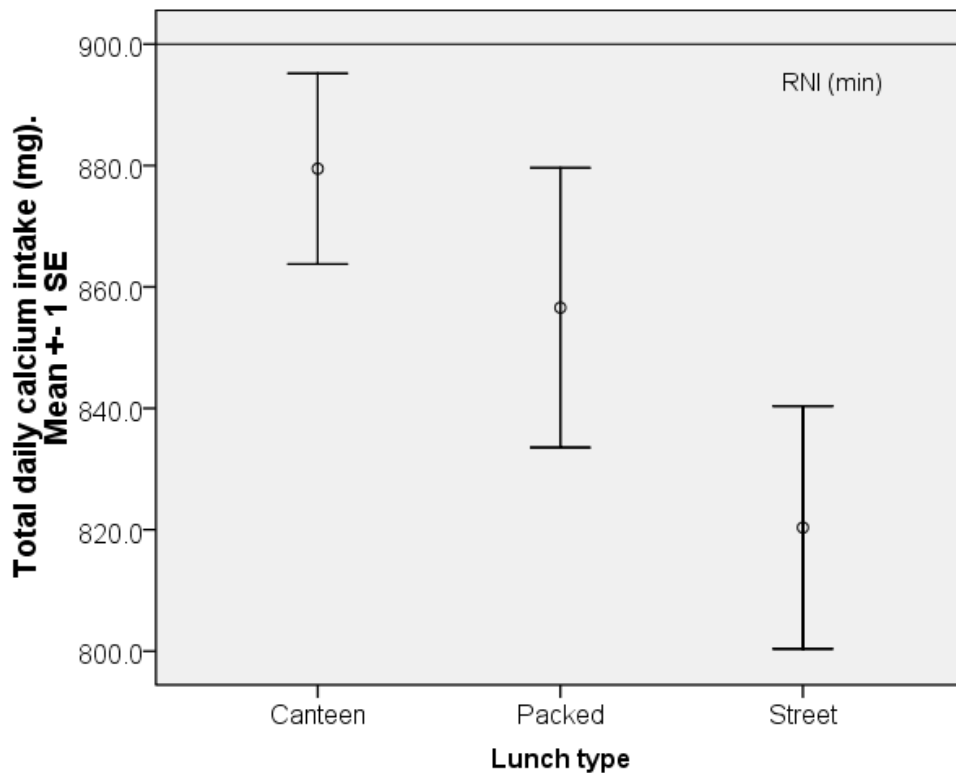


Figure 38: Daily calcium intake (mg), on canteen, packed and street lunch days. Standard Error of Mean. RNI (900mg) also shown for comparison
Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

No significant difference was detected between the calcium intakes for canteen, packed and street lunch days

Whole day iron intake

Packed lunch days had a higher mean iron intake (9.8mg) than those including packed or street lunches (9.6mg). One-way between-groups ANOVA was conducted to compare the mean iron intake for canteen, packed and street lunch days. There was no statistically significant difference between the iron intakes of the three groups.

Daily iron intake for canteen, packed and street lunch days is compared in Figure 39.

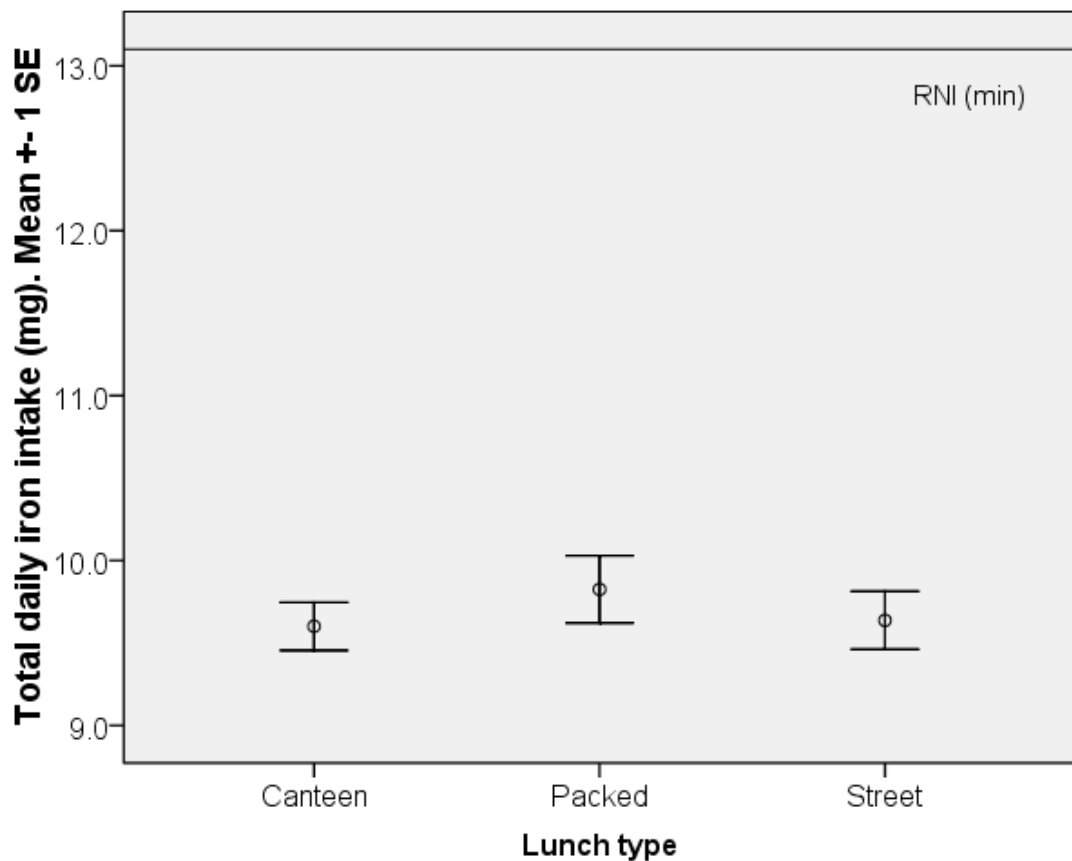


Figure 39: Daily iron intake (mg), on Canteen, Packed and Street Lunch days. Standard Error of Mean. RNI (13.1g) also shown for comparison

Circle at midpoint of error bars represents mean.

No significant difference was detected between the iron intakes for canteen, packed and street lunch days

Whole day – fruit and vegetable intake

Packed lunch days had the highest mean fruit and vegetable intake (1.8 portions), followed by canteen lunch days (1.4 portions), with street lunch days having the lowest (0.9 portions). One-way between-groups ANOVA was conducted to compare mean fruit and vegetable intake (portions) for canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the difference in the mean fruit and vegetable intake between each of the three groups was statistically significant ($p < 0.001$).

Daily fruit/vegetable intake for canteen, packed and street lunch days are compared in Figure 40.

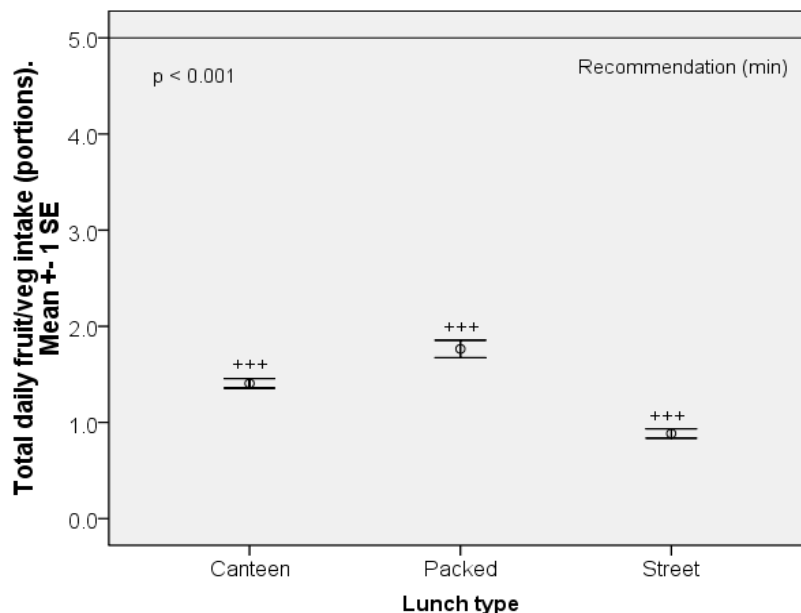


Figure 40: Daily fruit and vegetable intake (portions), for canteen, packed and street lunches. Standard Error of Mean.

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street, and packed vs street

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

3.6.4) *Percentage of canteen, packed and street lunches meeting EAR / RNI / LRNI / recommendation*

Table 22: Percentage of canteen, packed and street lunch days meeting the EAR / RNI and LRNI where applicable

NUTRIENT	CANTEEN	PACKED	STREET
Energy (Kcal)	36.8%	46.3%	41.6%
Fat (g)	60%	45%	33.7%
SFA (g)	40.6%	27.8%	23.3%
NMES (g)	43.1%	29.1%	20.8%
NSP (g)	7.3% (37.8%)	9.4% (38.2%)	5.0% (35.9%)
Vitamin A (ug)	31.7% (72.3%)	38.5% (80.9%)	30.0% (72.0%)
Folate (ug)	42.9% (89.3%)	41.7% (84.5%)	33.9% (83.3%)
Calcium (mg)	43.5% (86.6%)	39.8% (85.1%)	38.8% (81.4%)
Iron (mg)	15.0% (73.4%)	18.8% (77.3%)	15.5% (77.5%)
Fruit/vegetables (portions)	2.5%	5.5%	0%

(Figures meeting LRNI in brackets)

The percentage of canteen, packed and street lunch days meeting the EAR, RNI or recommendation is shown in Figure 41:

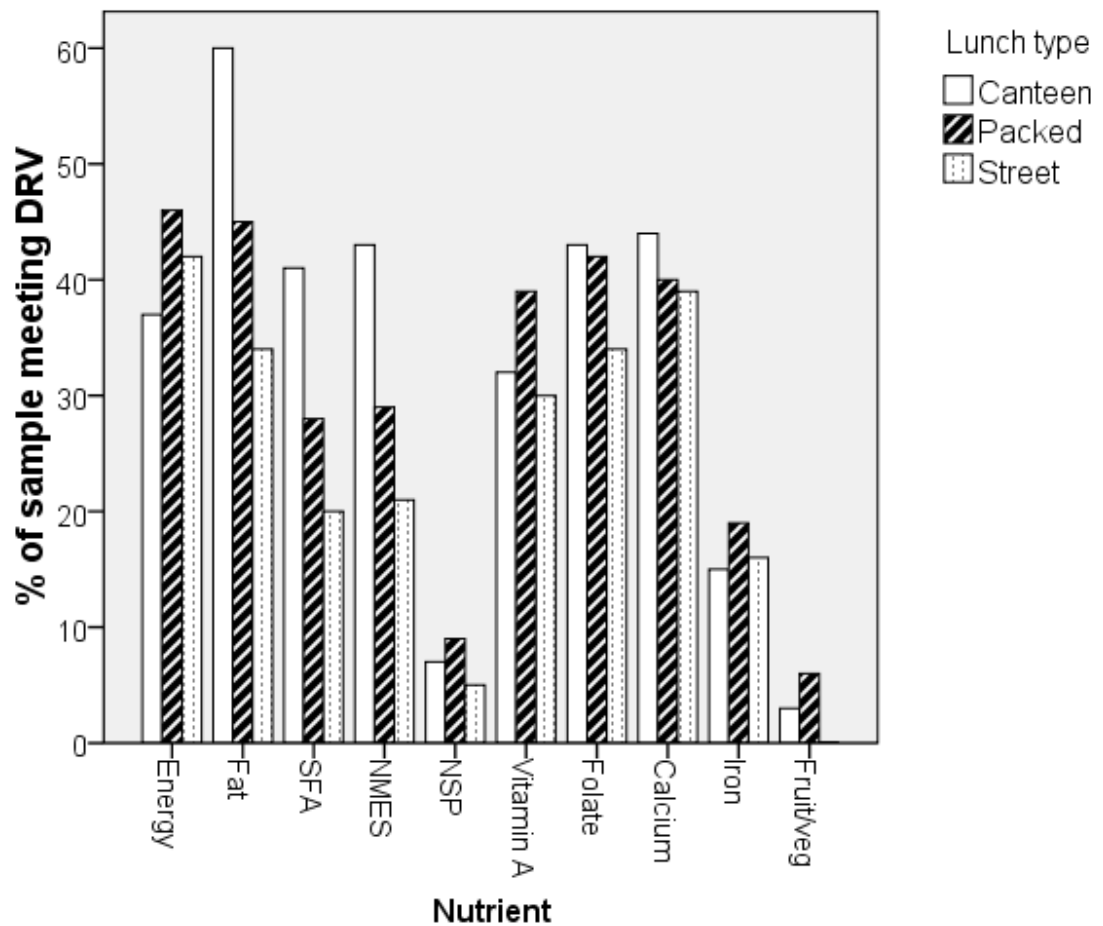


Figure 41: Percentage of canteen, packed and street lunch days meeting EAR, RNI or recommendation

3.7) Analysis of total daily nutrient density data – split by lunch type

For the following analyses, the sample was split according to which lunch type (canteen, packed or street) a day's data included.

3.7.1) Comparison of mean total daily nutrient densities for canteen, packed and street lunch days, with that of a hypothetical day meeting the DRV for the nutrients considered

Nutrient densities were calculated, to enable another means of comparison of canteen, packed and street lunch days. Nutrient densities from the present study were compared with nutrient densities for a hypothetical 'adequate' day precisely meeting the Dietary Reference Values for the various nutrients (as well as the Government target of 5 fruit and vegetable portions per day).

Nutrient density for canteen, packed and street lunch days was calculated by dividing daily intake of each nutrient analysed by mean daily energy intake (kcal). Because the nutrient intakes were measured using different units (grams, milligrams and micrograms), nutrient densities for the different nutrients could not be directly compared. However, it was possible to compare the nutrient densities for canteen, packed and street lunch days with the hypothetical 'adequate/desired nutrient density' day. In order to provide a comparison of density across the nutrients, density provided by lunch types in the present study was expressed as a percentage of density provided by the hypothetical day, and expressed graphically. To make the results of the analysis easier to interpret, nutrient densities were expressed per 100kcal.

The EAR for energy (averaged for boys and girls aged 11 – 14 years) is for a daily energy intake of 2,033kcal. In the present study, the mean energy intake was 1,877kcal for canteen lunch day, 1,990kcal for packed lunch days, and 2,174kcal for street lunch days.

One sample T-tests were used to compare mean total daily nutrient densities for canteen, packed and street lunch days, with those of a hypothetical day providing the DRVs for the nutrient considered (plus the recommendation for fruit/vegetables), to determine whether significant differences were present.

Table 23: Total daily nutrient densities (per 100kcal), mean and standard deviation. Present study compared with hypothetical day meeting DRVs. Standard deviation in brackets. P values indicated by asterisks

Nutrient	Hypothetical day meeting DRV	Whole sample	Canteen	Packed	Street
Fat (g/100kcal)	3.89	4.11 *** (0.11)	3.95 NS (0.83)	4.24 *** (0.82)	4.30 *** (0.72)
SFA (g/100kcal)	1.22	1.62 *** (0.49)	1.59 *** (0.51)	1.69 *** (0.51)	1.60 *** (0.44)
NMES (g/100kcal)	2.75	3.97 *** (3.42)	3.22 *** (2.87)	4.40 (3.62) ***	4.94 (3.83) ***
NSP (g/1,00kcal)	0.89	0.56 *** (0.21)	0.59 *** (0.22)	0.57 *** (0.23)	0.50 *** (0.19)
Vitamin A (ug/100kcal)	26.09	26.37 NS (36.19)	29.01 NS (40.78)	36.63 *** (32.62)	14.07 *** (25.66)
Folate (ug/100kcal)	9.84	8.00 *** (7.32)	10.18 NS (5.79)	7.93 *** (10.54)	4.36 *** (4.78)
Calcium (mg/100kcal)	44.27	38.81 *** (27.61)	47.14 *** (17.97)	42.82 NS (16.12)	37.37 *** (14.14)
Iron (mg/100kcal)	0.64	0.37 *** (0.21)	0.53 *** (0.19)	0.50 *** (0.17)	0.46 *** (0.18)
Fruit/veg (portions/100kcal)	0.25	0.07 *** (0.08)	0.08 *** (0.08)	0.09 *** (0.09)	0.04 *** (0.06)

*** = p < 0.001 NS = not significant

It was noted that the standard deviation for mean vitamin A was particularly high. This correlates with the characteristic high variability of intake for this vitamin.

Comparison of total daily nutrient density for fat

Street lunch days (4.30g/100kcal) and packed lunch days (4.24g/100kcal) both had significantly higher nutrient densities for fat ($p < 0.001$) than a hypothetical day (3.89g/100kcal) meeting the DRV for fat. The difference in nutrient density between the hypothetical day and a canteen lunch day (3.95g/100kcal) did not reach statistical significance.

Comparison of total daily nutrient density for SFA

Packed lunch days (1.69g/kcal), street lunch days (1.60g/100kcal) and canteen lunch days (1.62g/100kcal) all had significantly higher nutrient densities for SFA ($p < 0.001$) than a hypothetical day (1.22g/100kcal) meeting the DRV for fat.

Comparison of total daily nutrient density for NMES

Street lunch days (4.94g/100kcal), packed lunch days (4.40g/100kcal) and canteen lunch days (3.22g/100kcal) all had significantly higher nutrient densities for NMES ($p < 0.001$) than a hypothetical day (2.75g/100kcal) meeting the DRV for fat.

Comparison of total daily nutrient density for NSP

Street lunch days (0.50g/100kcal), packed lunch days (0.57g/100kcal) and canteen lunch days (0.59g/100kcal) all had significantly lower nutrient densities for NSP than a hypothetical day (0.89g/100kcal) meeting the DRV for NSP.

Comparison of total daily nutrient density for vitamin A

The mean vitamin A density for packed lunch days (36.63ug/100kcal) exceeded that for a hypothetical day (26.09ug/100kcal) meeting the DRV for vitamin A ($p < 0.001$). The mean vitamin A density for canteen lunch days (29.01ug/100kcal) also exceeded that for the hypothetical day, but this difference did not reach statistical significance. Street lunch days had a mean nutrient density for vitamin A (14.07ug/100kcal) that was significantly lower ($p < 0.001$) than that for a hypothetical day meeting the DRV.

Comparison of total daily nutrient density for folate

The mean folate density for street lunch days (4.36ug/100kcal) was significantly less than that for a hypothetical day (9.84ug/100kcal meeting the DRV for folate ($p < 0.001$)). The mean folate density for packed lunch days (7.93ug/100kcal) was also significantly less than that for the hypothetical day, but $p < 0.05$. The mean folate density for canteen lunch days (10.18ug/100kcal) exceeded that for the hypothetical day, but this difference did not reach statistical significance.

Comparison of total daily nutrient density for calcium

The mean calcium for canteen lunch days (33.81mg/100kcal) exceeded that for a hypothetical day (44.27mg/100kcal) meeting the DRV for calcium ($p < 0.001$). Street lunch days had a mean calcium density (37.37mg/100kcal) that was significantly lower ($p < 0.001$) than that for a hypothetical day meeting the DRV. The mean calcium density for packed lunch days (29.01ug/100kcal) was also lower than that for the hypothetical day, but this difference did not reach statistical significance.

Comparison of total daily nutrient density for iron

Street lunch days (0.46mg/100kcal), packed lunch days (0.50mg/100kcal) and canteen lunch days (0.53mg/100kcal) all had significantly lower mean nutrient densities for iron than a hypothetical day (0.64mg/100kcal) meeting the DRV for iron ($p < 0.001$).

Comparison of total daily fruit and vegetable density

Street lunch days (0.04 portions/100kcal), canteen lunch days (0.08 portions/100kcal) and packed lunch days (0.09 portions/100kcal) all had significantly lower mean fruit and vegetable densities than a hypothetical day (0.25 portions/100kcal) meeting the Government recommendation for fruit and vegetable intake ($p < 0.001$).

To compare the nutrient density of canteen, packed and street lunch days with that of a hypothetical lunch providing the DRV for each of the nutrients considered in the present study (plus fruit and vegetables), their nutrient densities were expressed as a percentage of the nutrient densities of the hypothetical 'adequate' day.

A comparison of the mean nutrient densities for fat, SFA and NMES (those for which RNI's are set as maximum values), on canteen, packed and street lunch days, as a percentage of that provided by a day providing the DRV lunch meeting the SNSSL requirements, can be seen in Figure 42.

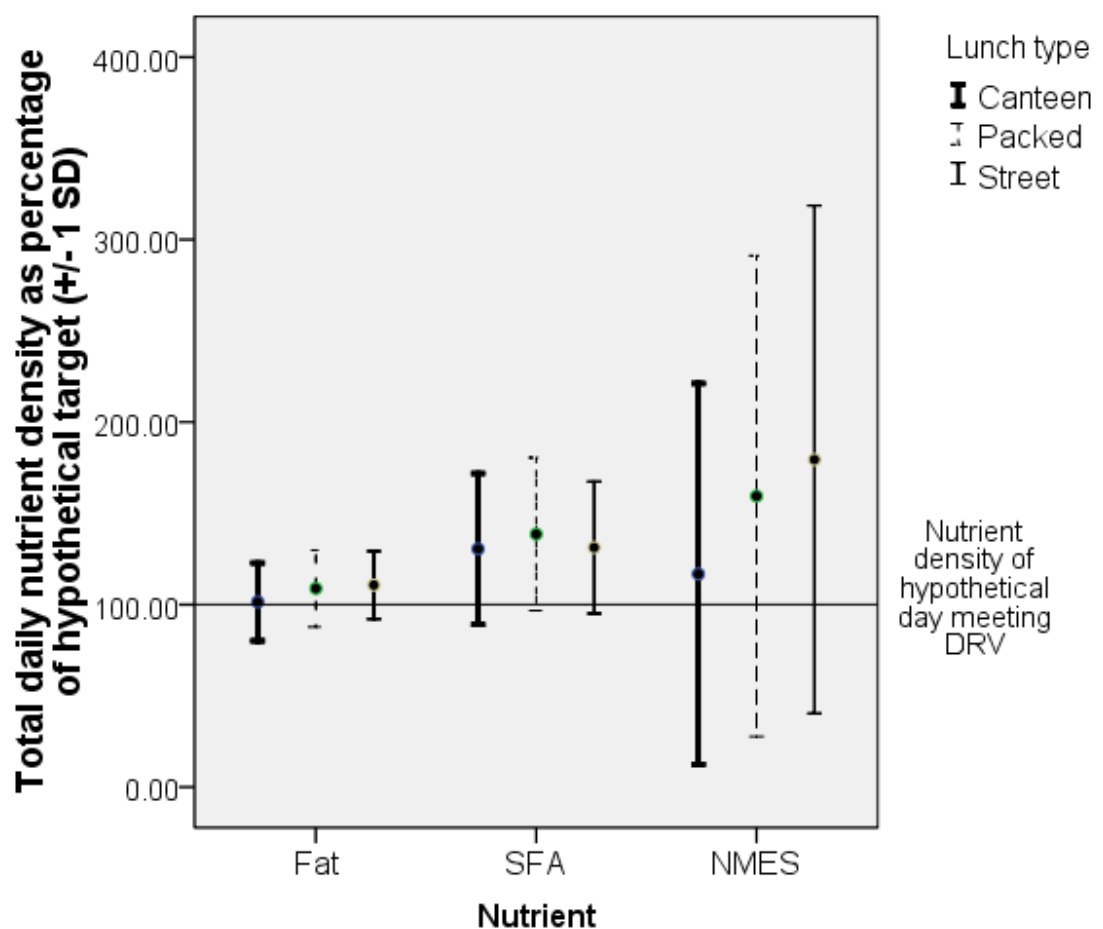


Fig 42: Mean nutrient density for canteen, packed and street lunch days, as % of that provided by a day providing the DRV. Nutrients for which DRV is a maximum (fat, SFA and NMES)

A comparison of the mean nutrient densities for NSP, micronutrients, plus fruit and vegetables (for which the RNIs and the Government recommendation are set as minimum values), on canteen, packed and street lunch days, as a percentage of that on a hypothetical day providing the DRV lunch meeting the SNSSL requirements, can be seen in Figure 43.

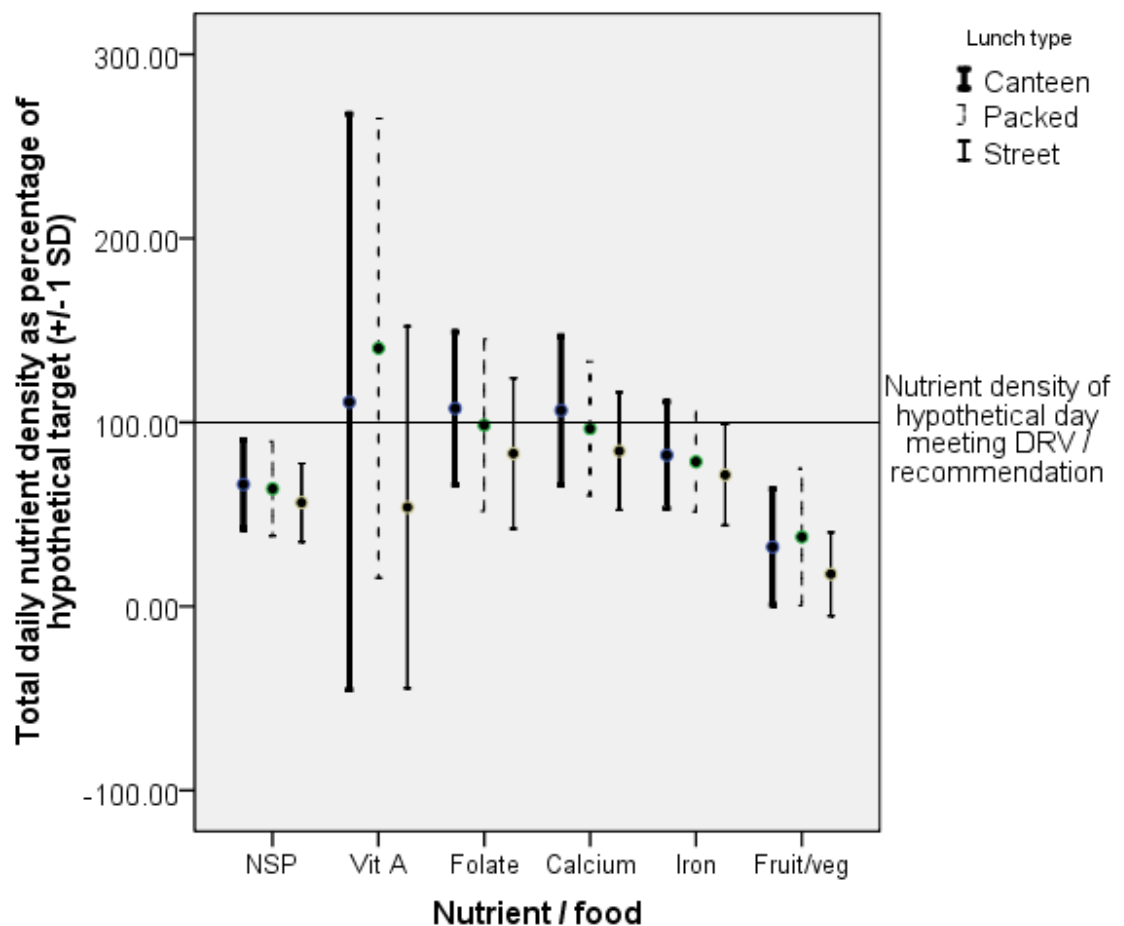


Fig 43: Mean nutrient/food density for canteen, packed and street lunch day, as % of that found on a day providing the RNI/recommendation. Nutrients/foods for which RNI/recommendation is a minimum (NSP, vitamin A, folate, calcium, iron and fruit/vegetables)

3.7.2) Ranking of canteen, packed and street lunch days, showing the most and least favourable nutrient density (whether that is high or low) for nutrients included in the SNSSL

Canteen lunch days showed the most favourable nutrient density in the present study, for fat, NMES, NSP, folate, calcium and iron. Canteen lunch days were slightly more favourable in nutrient density terms than the nutrient density provided by a hypothetical day meeting the SNSSL.

Canteen lunch days did not show the least favourable nutrient density for any nutrient. Compared with a hypothetical day meeting the DRV, canteen lunch days showed a more favourable nutrient density for calcium ($p < 0.01$). Canteen lunch days showed a less favourable nutrient density than a hypothetical day meeting the DRV, regarding SFA, NMES, NSP, iron, and fruit and vegetables ($p < 0.001$). The differences in nutrient density for fat, vitamin A and folate between the groups were not statistically significant.

Packed lunch days showed the most favourable nutrient density for vitamin A, and fruit and vegetables. They exceeded the nutrient density provided by the hypothetical lunch meeting the DRV for vitamin A, but not for fruit and vegetables.

Packed lunch days showed the least favourable nutrient density for SFA. Compared with a hypothetical day meeting the DRV, packed lunch days showed a more favourable nutrient density for fat, vitamin A, folate and calcium ($p < 0.001$ for fat, vitamin A and calcium, $p < 0.01$ for folate). They showed a less favourable nutrient density than a hypothetical day meeting the DRV, regarding fat, SFA, NMES, folate, calcium, iron, and fruit and vegetables ($p < 0.001$). The difference in nutrient density for NSP between packed lunch days and the hypothetical day was not statistically significant.

Street lunch days did not show the most favourable nutrient density for any nutrient. Street lunch days showed the least favourable nutrient density for fat, NMES, NSP, vitamin A, folate, calcium, iron, and fruit and vegetables. Compared with a hypothetical day meeting the DRV, street lunch days showed a less favourable nutrient density for every nutrient analysed ($p < 0.001$).

3.7.3) Detection and location of significant differences between nutrient densities for canteen, packed and street lunch days

One-way between-groups analysis of variance (ANOVA) and Post-hoc tests (Tukey's) were used to compare the nutrient densities of the three lunch types. In common with the situation for lunchtime nutrient densities - the greatest differences (in nutrient density between canteen, packed and street lunch days) were found for folate and calcium, with canteen lunch days providing the most favourable nutrient densities.

P values indicating presence of significant difference between days including the lunch types are shown at the top left of the following figures. For visual comparison, a horizontal line denotes the nutrient density of a hypothetical day's nutrient density precisely meeting the appropriate DRV or recommendation. These figures do not show the P values for significant differences between total daily densities and the hypothetical targets – this information can be found in Table 23.

Whole day nutrient density for fat

Canteen lunch days had a lower fat density (3.95g/100kcal) than street lunch days (4.30g/100kcal) and packed lunch day (4.24g/100kcal). One-way ANOVA was conducted to compare the mean nutrient density for fat, for canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for fat on canteen lunch days was significantly lower than that for canteen and street lunch days ($p < 0.001$). The difference between the nutrient densities for packed and street lunch days was not statistically significant.

Fat density on canteen, packed and street lunch days is compared in Figure 44.

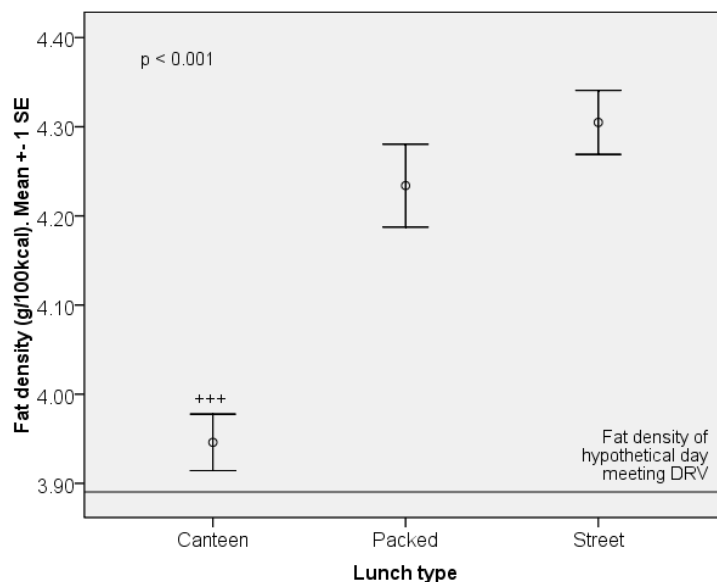


Figure 44: Nutrient density for fat (g/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. Fat density (3.85g/100kcal) of hypothetical day meeting DRV also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street lunch days

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = NS

Whole day nutrient density for SFA

The significance of the differences between the lunch types was less for SFA than for the other nutrients and foods considered. Packed lunch days (1.69g/100kcal) had a higher SFA density than street lunch days (1.60g/100kcal) or canteen lunch days (1.59g/100kcal). One-way ANOVA was conducted to compare the mean SFA density on canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for SFA on packed lunch days was significantly higher than that on street lunch days ($p < 0.05$), and also higher than that on canteen lunch days ($p < 0.01$). Mean SFA density on street lunch days was marginally higher than that for canteen lunch days, but this difference failed to reach statistical significance.

SFA density on canteen, packed and street lunch days is compared in Figure 45.

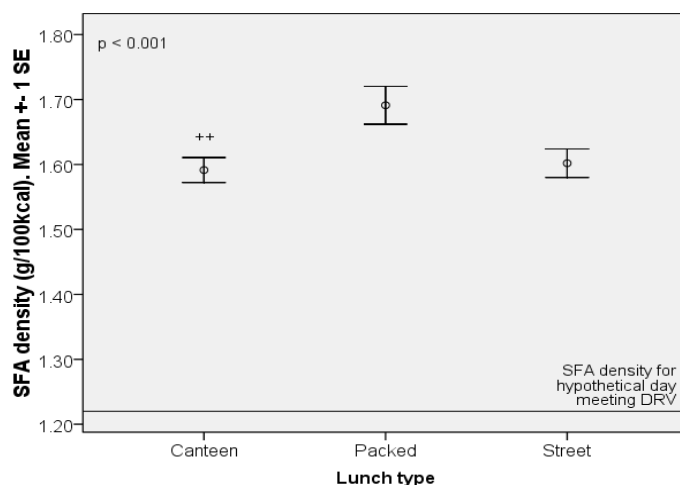


Figure 45: Nutrient density for SFA (g/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. SFA density (1.22g/100kcal) of hypothetical day meeting DRV also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

++ = $p < 0.01$ for comparison of canteen vs packed lunch days

+ = $p < 0.05$ for comparison of packed vs street lunch days

Canteen vs packed = ++ Canteen vs street = NS Packed vs street = +

Whole day nutrient density for NMES

Street lunch days (4.94g/100kcal) had a higher NMES density than packed lunch days (4.40g/100kcal) or canteen lunch days (3.21g/100kcal). One-way ANOVA was conducted to compare the mean nutrient density for NMES, for canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for NMES on canteen lunch days was significantly lower ($p < 0.001$) than on packed or street lunch days. The mean nutrient density for NMES on packed lunch days was marginally lower than on street lunch days, but this difference did not reach statistical significance.

NMES density on canteen, packed and street lunch days is compared in Figure 46.

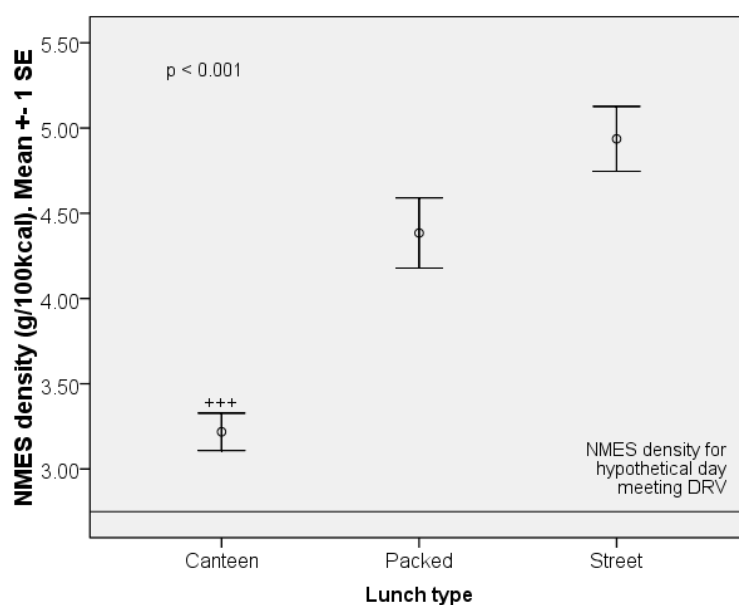


Figure 46: Nutrient density for NMES (g/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. NMES density (2.75g/100kcal) of hypothetical day meeting DRV also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of canteen vs packed and street lunch days

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = not signif

Whole day nutrient density for NSP

Canteen lunch days had a higher NSP density (0.59g/100kcal) than packed (0.57g/100kcal) or street lunch days (0.50g/100kcal). One-way ANOVA was conducted to compare mean nutrient density for NSP, on canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for NSP on street lunch days was significantly lower ($p < 0.001$) than on packed lunch days or canteen lunch days (the highest NSP density). Mean nutrient density for NSP on packed lunch days was marginally lower than street lunch days, but this difference did not reach statistical significance. This was the same pattern of significant differences and significance levels shown by lunchtime nutrient densities for NSP.

NSP density on canteen, packed and street lunch days is compared in Figure 47.

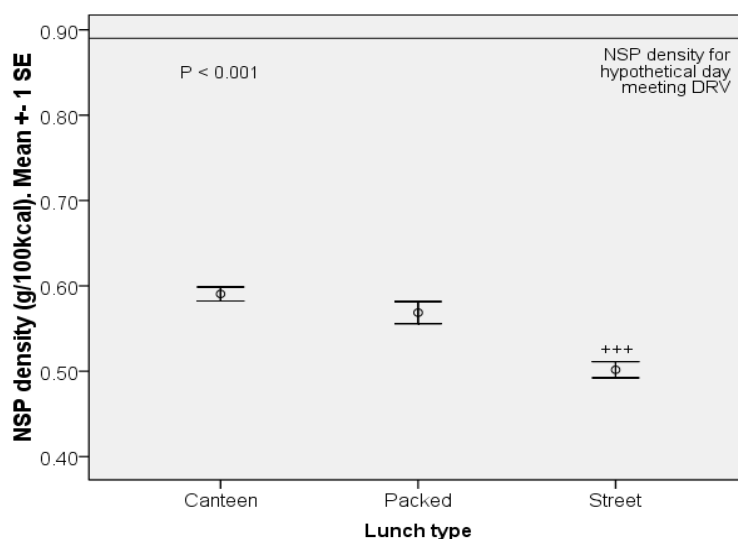


Figure 47: Nutrient density for NSP (g/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. NSP density (0.89g/100kcal) of hypothetical day meeting DRV also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of street vs canteen and packed lunch days

Canteen vs packed = NS Canteen vs street = +++ Packed vs street = +++

Whole day nutrient density for vitamin A

Packed lunch days had a higher vitamin A density (36.63ug/100kcal) than canteen (29.01ug/100kcal) or street lunch days (14.07ug/100kcal). One-way ANOVA was conducted to compare mean nutrient density of vitamin A, on canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for vitamin A in packed lunch days (highest density) was significantly higher than that for canteen lunch days ($p < 0.01$). In turn, mean nutrient density for canteen lunch days was significantly higher than that for street lunch days, and to a higher level of significance ($p < 0.001$).

Vitamin A density on canteen, packed and street lunch days is compared in Figure 48.

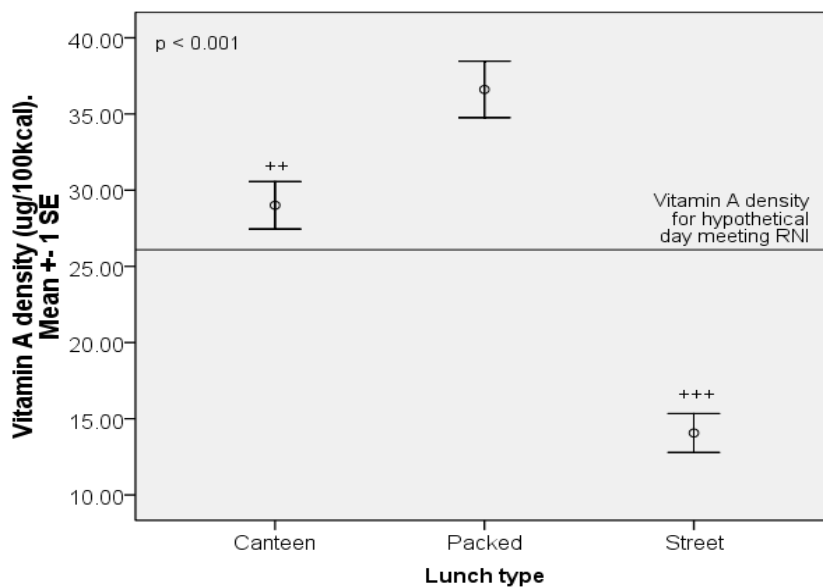


Figure 48: Nutrient density for vitamin A (ug/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. Vitamin A density (26.09ug/100kcal) of hypothetical day meeting RNI also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of street vs canteen and packed lunch days

++ = $p < 0.01$ for comparison of canteen vs packed lunch days

Canteen vs packed = ++ Canteen vs street = +++ Packed vs street = +++

Whole day nutrient density for folate

Canteen lunch days had a higher nutrient folate density (10.18ug/100kcal) than packed (7.93ug/100kcal) or street lunch days (4.36ug/100kcal). One-way ANOVA was conducted to compare mean nutrient density of folate on canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for folate on days including each of the three lunch types – canteen, packed and street – was significantly different ($p < 0.001$).

Folate density on canteen, packed and street lunch days is compared in Figure 49.

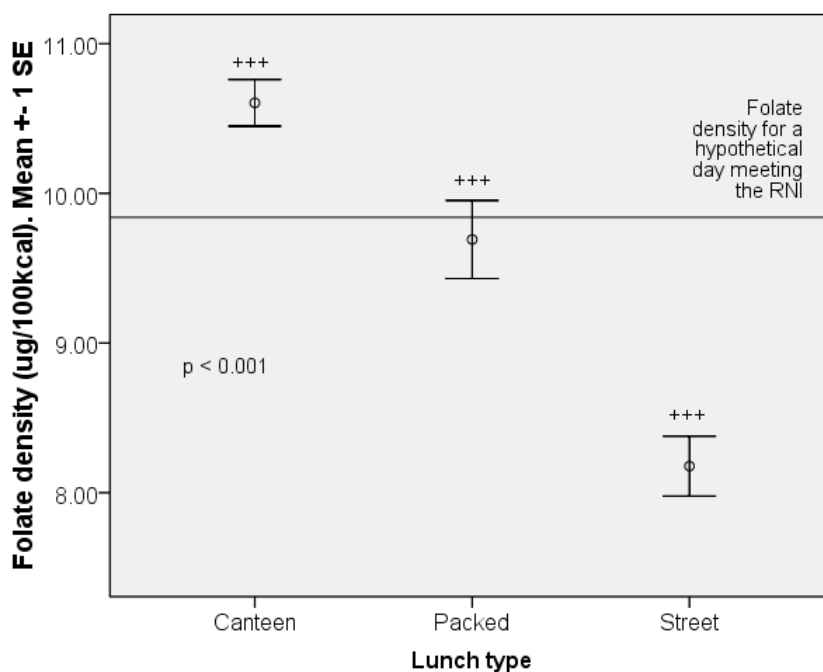


Figure 49: Nutrient density for folate (ug/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. Folate density (9.84ug/100kcal) of hypothetical day meeting RNI also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison between days including each of the lunch types

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Whole day nutrient density for calcium

Canteen lunch days had a higher calcium density (47.14mg/100kcal) than packed (42.82mg/100kcal) or street lunch days (37.37mg/100kcal). One-way ANOVA was conducted to compare mean nutrient density of calcium on canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for calcium, on days including canteen, packed and street lunch days was significantly different ($p < 0.001$).

Calcium density on canteen, packed and street lunch days is compared in Figure 50.

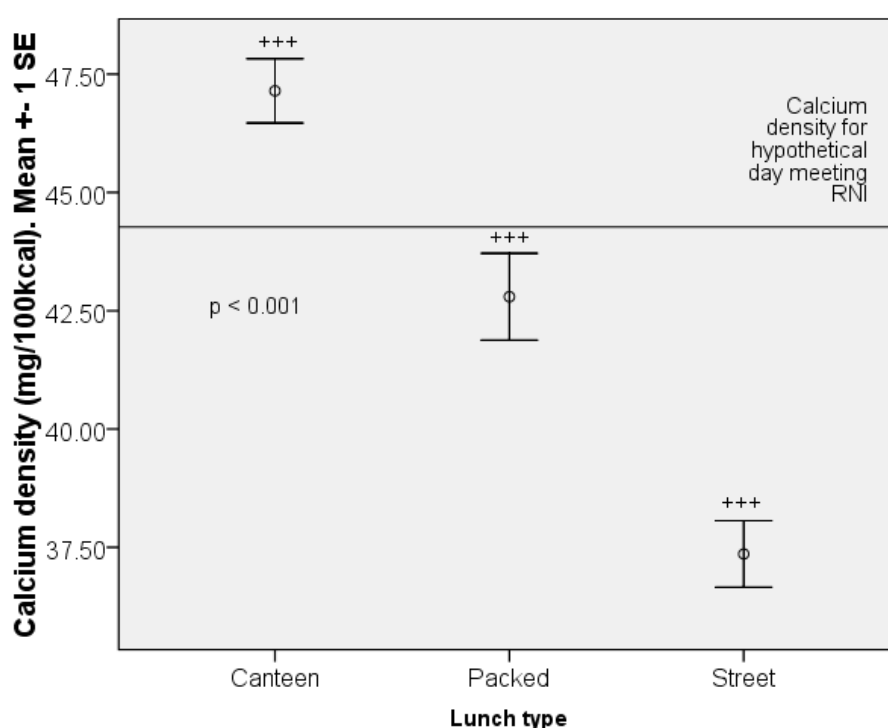


Figure 50: Nutrient density for calcium (mg/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. Calcium density (44.27mg/100kcal) of hypothetical day meeting RNI also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison between days including each of the lunch types

Canteen vs packed = +++ Canteen vs street = +++ Packed vs street = +++

Whole day nutrient density for iron

Canteen lunch days had a higher iron density (0.53mg/100kcal) than packed (0.50mg/100kcal) or street lunch days (0.46mg/100kcal). One-way ANOVA was conducted to compare mean iron density on canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that the mean nutrient density for iron on canteen lunch days (highest density) was significantly higher than on street lunch days (lowest density), $p < 0.001$. Mean iron density on packed lunch days was significantly higher than on street lunch days, but to a lesser extent ($p < 0.01$). Mean iron density on canteen lunch days was marginally higher than on packed lunch days, but this difference did not reach statistical significance.

Iron density on canteen, packed and street lunch days is compared in Figure 51



Figure 51: Nutrient density for iron (mg/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. Iron density (0.64mg/100kcal) of hypothetical day meeting RNI also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

$p < 0.001$ for comparison of canteen vs street lunch days

++ = $p < 0.01$ for comparison of packed and street lunch days

Canteen vs packed = NS Canteen vs street = +++ Packed vs street = ++

Whole day density for fruit and vegetables

Packed lunch days had a higher fruit and vegetable density (0.09 portions/100kcal) than canteen (0.08 portions/100kcal) or street lunch days (0.04 portions /100kcal). One-way ANOVA was conducted to compare the mean fruit and vegetable density on canteen, packed and street lunch days. A statistically significant difference was detected ($p < 0.001$). Post-hoc comparisons (Tukey's test) indicated that mean fruit and vegetable density on street lunch days (lowest density) was significantly lower than on canteen, or packed lunch days (highest density), $p < 0.001$. Fruit and vegetable density on packed lunch days was significantly higher than that on canteen lunch days, $p < 0.05$.

Portion density for fruit and vegetables on canteen, packed and street lunch days is compared in Figure 52

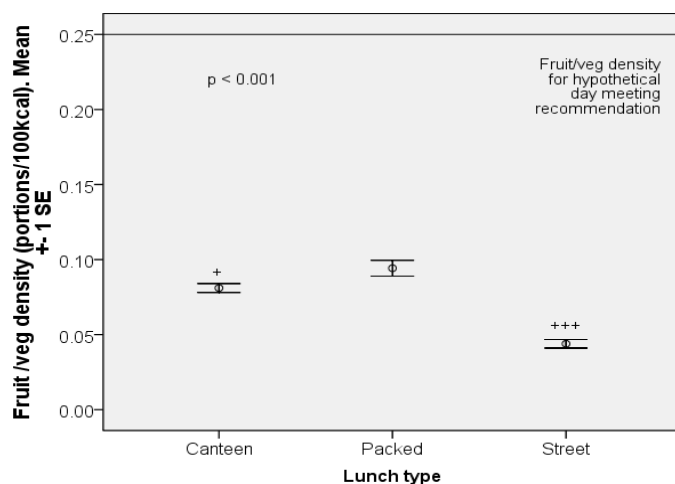


Figure 52: Food portion density for fruit/vegetables (portions/100kcal) on canteen, packed and street lunch days, Standard Error of Mean. Fruit/vegetable density (0.25 portions/100kcal) of hypothetical day meeting Government recommendation also shown for comparison

Circle at midpoint of error bars represents mean.

P value = significant difference between canteen, packed and street lunch days

Post-hoc values (Tukey's):

+++ = $p < 0.001$ for comparison of street vs canteen and packed lunch days

+ = $p < 0.05$ for comparison of canteen and packed lunch days

Canteen vs packed = +

Canteen vs street = +++

Packed vs street = +++

3.8) Comparison of lunchtime data with that from the whole day

3.8.1) Percentage of total daily intake provided by lunch on canteen, packed and street lunch days

To ascertain the importance of the lunchtime meal in terms of its contribution towards total nutrient intake, the percentage of total daily intake provided by lunch was calculated for canteen, packed and street lunches.

Table 24: Percentage of total daily intake provided by canteen, packed and street lunch.
Standard deviation in brackets

NUTRIENT	CANTEEN (SD)	PACKED (SD)	STREET (SD)
Kcal	28.5 (12.0)	28.5 (9.6)	32.8 (11.5)
Fat	26.6 (14.0)	32.0 (14.6)	35.2 (16.5)
SFA	27.6 (17.1)	34.4 (19.3)	32.9 (18.6)
NMES	26.3 (22.5)	29.9 (29.5)	36.7 (22.6)
NSP	29.9 (17.2)	25.1 (14.7)	24.9 (17.8)
Vitamin A	30.2 (27.8)	36.1 (24.9)	19.2 (24.8)
Folate	28.1 (16.4)	25.9 (54.1)	17.7 (15.9)
Calcium	29.5 (19.3)	25.9 (16.5)	22.6 (17.9)
Iron	24.9 (24.7)	20.2 (10.9)	22.4 (20.5)
Fruit/vegetables	20.3 (33.7)	28.0 (36.5)	8.6 (24.8)

3.8.2) *Ability of lunchtime intake to meet SNSSL standard, against ability of total daily intake to meet EAR, DRV, RNI or Government recommendation. Comparison of canteen, packed and street lunches*

Table 25: Mean intake as percentage of appropriate standard (SNSSL for lunch; EAR, DRV or recommendation for whole day) for lunchtime and whole day, split by lunch type

		Standard	CANTEEN	PACKED	STREET
Lunch	Energy	646kcal	78%	86%	109%
Whole day	Energy	2033kcal	92%	93%	107%
Lunch	Fat	25.1g	72%	104%	128%
Whole day	Fat	79.0g	94%	109%	119%
Lunch	SFA	7.9g	96%	149%	137%
Whole day	SFA	24.9g	120%	137%	141%
Lunch	NMES	18.0g	88%	137%	197%
Whole day	NMES	55.9g	125%	146%	167%
Lunch	NSP	5.2g	58%	50%	54%
Whole day	NSP	18g	61%	62%	59%
Lunch	Vitamin A	185ug	70%	109%	52%
Whole day	Vitamin A	600ug	86%	99%	81%
Lunch	Folate	80ug	63%	50%	37%
Whole day	Folate	200ug	98%	94%	86%
Lunch	Calcium	350mg	68%	63%	51%
Whole day	Calcium	900ug	98%	95%	91%
Lunch	Iron	5.9mg	36%	32%	34%
Whole day	Iron	13.1mg	73%	75%	73%
Lunch	Fruit/veg	2 portions	14%	24%	5%
Whole day	Fruit/veg	5 portions	28%	36%	18%

In Table 25 (previous page) bold figures indicate failure to meet standard. Values stated for standards are average for male/female age 11-14. (The figure in the table for energy is an 'ideal' target, rather than a maximum or minimum as for the other nutrients).

The percentage of SNSSL, EAR or RNI provided by lunch and total day's intake – energy, fat, SFA and NMES can be seen in Figure 53.

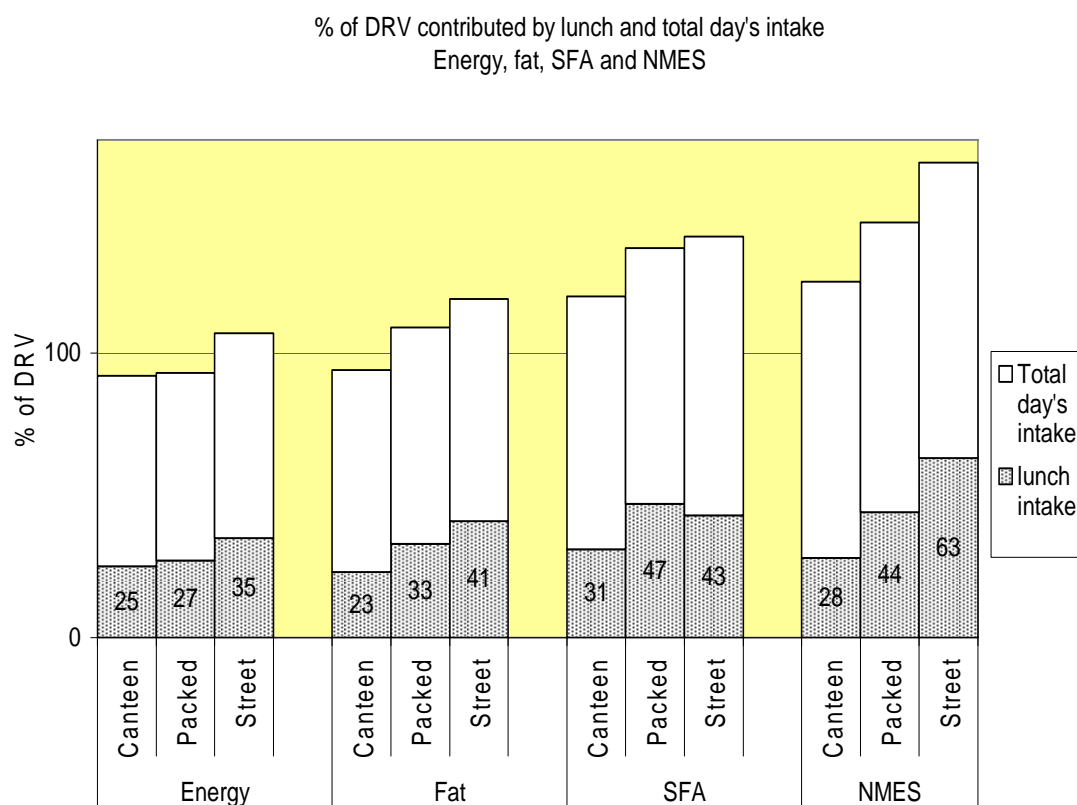


Fig 53: Percentage of SNSSL standard/EAR/DRV/recommendation provided by lunch and total day's intake (mean values) – Energy (for which SNSSL standard is a target), fat, SFA and NMES (for which SNSSL standard is set as a maximum). Comparison of canteen, packed and street lunches

The percentage of the SNSSL standard, RNI or Government recommendation provided by lunch and total day's intake, for NSP, micronutrients, fruit/vegetables (nutrients/foods for which SNSSL standard/RNI or recommendation are set as minimums) – can be seen in Figure 54.

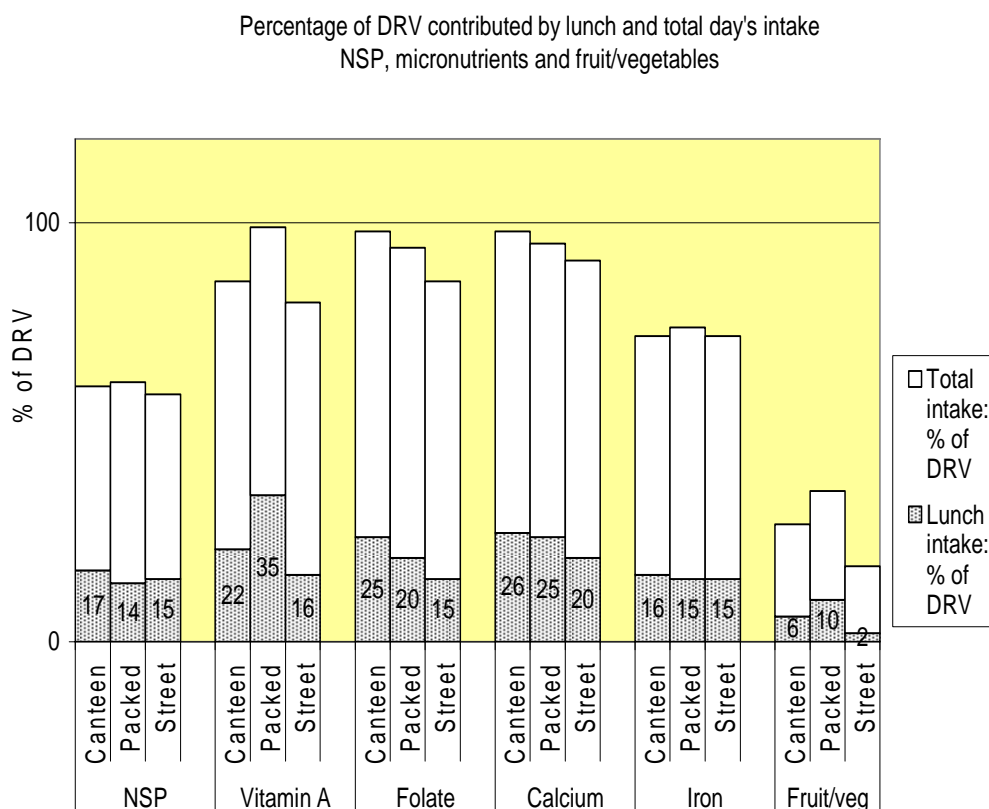


Fig 54: Percentage of SNSSL standard/RNI/recommendation provided by lunch and total day's intake (mean values) – NSP, micronutrients, fruit/vegetables (nutrients/foods for which SNSSL standard/RNI or recommendation are set as a minimum). Comparison of canteen, packed and street lunches

Table 26: Percentage of sample meeting the appropriate target (SNSSL for lunch; EAR, DRV, RNI or Government recommendation for whole day) for lunchtime and whole day (split according to lunch type)

	NUTRIENT	CANTEEN	PACKED	STREET
Lunch	Energy (kcal)	26.4%	47.6%	56.2%
<i>Whole day</i>	<i>Energy (kcal)</i>	36.8%	46.3%	41.6%
Lunch	Fat (g)	77.8%	52.4%	39.6%
<i>Whole day</i>	<i>Fat (g)</i>	60.0%	45.0%	33.7%
Lunch	SFA (g)	63.2%	40.5%	53.4%
<i>Whole day</i>	<i>SFA (g)</i>	40.6%	27.8%	23.3%
Lunch	NMES (g)	61.5%	45.6%	33.7%
<i>Whole day</i>	<i>NMES (g)</i>	43.1%	29.1%	20.8%
Lunch	NSP (g)	10.5%	7.4%	9.4%
<i>Whole day</i>	<i>NSP (g)</i>	7.3%	9.4%	5.0%
Lunch	Vitamin A (ug)	18.7%	46.3%	19.3%
<i>Whole day</i>	<i>Vitamin A (ug)</i>	31.7%	38.5%	30.0%
Lunch	Folate (ug)	16.9%	6.1%	5.4%
<i>Whole day</i>	<i>Folate (ug)</i>	42.9%	41.7%	33.9%
Lunch	Calcium (mg)	21.5%	21.1%	14.1%
<i>Whole day</i>	<i>Calcium (mg)</i>	43.5%	39.8%	38.8%
Lunch	Iron (mg)	0.3%	0.3%	0.5%
<i>Whole day</i>	<i>Iron (mg)</i>	15.0%	18.8%	16.0%
Lunch	Fruit/veg (portions)	3.6%	5.2%	0.7%
<i>Whole day</i>	<i>Fruit/veg (portions)</i>	2.5%	5.5%	0%

For the purposes of this table, 'meeting' the standard for energy indicates provision of more than the target energy intake

Figures meeting LRNI in brackets

Section 4 – discussion

4.1) Consideration of the nutrient intake of the whole sample

Compared with recommended intakes, the sample population's overall diets were nutritionally poor. Taken as a whole, although the sample's total energy intake was close to the Estimated Average Requirement (EAR), the children showed excessive intakes (higher than the DRV) of fat, SFA, and NMES, and insufficient intakes (below the DRV or RNI) of NSP, vitamin A, folate, calcium and iron. The deficiency seen in their fruit and vegetable intakes (compared with the Government recommendation (Department of Health 2003a) was even more extreme.

Considering fat, SFA and NMES, the mean intakes of the study sample exceeded the DRV by 4.5%, 29.6% and 41.8% respectively, with percentage energy from fat, SFA and NMES exceeding the recommendations by 6%, 33% and 43% respectively. This particularly high percentage of calories provided by SFA and NMES supports the concern voiced by many researchers and some of the popular media, that modern children's diets are too dense in fatty, sugary foods.

The children in the present study had mean intakes of micronutrients that were too low in comparison to recommendations. Although the mean intakes of calcium and folate were close to the RNI (95% and 93% respectively), the mean intake of vitamin A was 87% of the RNI, 74% for iron, and for fruit and vegetables just 26% of the Government recommendation (Department of Health 2003a).

However, comparing the mean intake of a population with a target or standard may give a misleading impression if the sample distribution is skewed towards low or high intakes, with an unexpectedly high proportion of the sample having intakes above or below the mean. In the present study, intakes of all nutrients showed positive skewness (intakes tending towards the low end of the distribution). The strongest skewness was seen for fruit and vegetable intake, followed by NMES, iron and calcium intakes. For fruit and vegetable intake, the median intake was zero portions.

This indication of a tendency towards lower intakes than the mean suggested that the proportion of days meeting the DRVs (RNI and LRNI) for nutrient intake is particularly relevant where NSP, vitamin A, folate, calcium, iron, and also fruit and vegetables, are concerned. It is possible that mean intakes could make the situation appear more acceptable than the reality, if large numbers of children's intakes tend towards the low end of the distribution of intakes.

For this reason, the percentage of the sample meeting recommendations was calculated and, as expected, this highlighted the fact that a large proportion of the sample population was consuming insufficient NSP, micronutrients and fruit and vegetables. It was discovered that only 16% of the sample met the RNI for iron, 7% for NSP, and only 2% met the Government recommendation for fruit and vegetable intake. The nutrients with the highest proportion of the sample meeting the RNI were folate and calcium (40%) followed by vitamin A (33%).

When the mean intakes were compared with the LRNI, which is the intake estimated as sufficient for just 2.5% of the population (those with particularly low requirements), only 74% - 87% reached this value for folate, calcium and iron. Only 37% met the LRNI for NSP (no LRNI exists for fruit and vegetable intake).

It is generally accepted that an intake below the LRNI is almost certainly insufficient regarding that particular nutrient, and the fact that the intakes so many of the days analysed in the present study were almost certainly deficient in NSP and micronutrients, has serious public health implications.

NSP has been found to have an inverse association with obesity, heart disease, colon and breast cancer, diabetes and gastrointestinal disorders (Institute of Food Science & Technology Trust Fund 2007). The diets of children in the present study were noticeably lacking in fibre-rich foods, such as wholegrains, fruit and vegetables, and their extremely low consumption of NSP, with 63% failing to meet the LRNI and 93% failing to meet the RNI, could lead to an increased risk of these diseases in later life. Fibre-rich foods also have a low glycaemic index, which increases satiety, and could

help them to resist snack foods between meals (Ball et al. 2003). This would be advantageous, since many of the snacks consumed in the present study were high in sugar and fat.

Vitamin A plays a role in immune function, and its antioxidant properties help reduce the risk of cardiovascular disease and cancer (Duthie et al. 1989), which are leading causes of death in Scotland (General Register Office for Scotland 2005). This makes it especially important for children to establish eating patterns that ensure sufficient intakes of vitamin A, especially since other characteristics of their diets (high in saturated fat, and low in NSP and fruit and vegetables) also predispose them to these diseases. Although the deficiency in intake of this vitamin seen in the present study was less extreme than for other nutrients, it is still cause for concern.

Folate is important for preventing neural tube defects during embryonic development, so an adequate intake is needed in women of reproductive age (Department of Health 2004), since it is possible that they may become pregnant. For this reason, the RNI increases from 110ug daily to 150ug when girls reach the age of 11. Only 40% of the sample met this RNI. Although it is undesirable for girls of the age surveyed in the present study to become pregnant, the possibility remains that they may do so. Also, they will soon be of an age where they may want to start a family, making it important that they develop eating patterns that encourage the consumption of foods rich in this vitamin.

Calcium was the micronutrient for which the mean intake in the present study came closest to achieving the RNI (mean = 95% of RNI). The proportion of days meeting the RNI for calcium was also higher than for any other micronutrient measured. However, the fact that more than half (60%) of the days surveyed had calcium intakes below the RNI, and 15% failed to meet the LRNI, is of concern, as this nutrient is particularly important during adolescence. A diet rich in calcium during the teenage years has been found to maximize bone density and therefore be protective against bone thinning later in life (Sandler et al. 1985).

Low iron intakes are known to be a matter of concern in children's diets (Department of Health 1989; Gregory & Lowe 2000) and the present study supported this concern. Iron was the micronutrient showing the greatest shortfall in intake in the present study, with the mean intake providing 74% of the RNI, and 84% of the days analysed failing to reach the RNI. Emphasising the fact that this is a matter of concern is the finding that 24% of days failed to reach even the LRNI.

Despite being foods rather than nutrients, fruit and vegetables were analysed in the present study in the light of children's poor intake in previous studies such as the NDNS for young people (Gregory & Lowe 2000), and the author's observation in previous research (Norris 2005) that street lunches are extremely lacking in these foods. Fruit and vegetable intake is also a good indicator of dietary quality. They are low in fat and NMES, and high in NSP and vitamin A (due to their beta-carotene content). Fruit and vegetables are also rich in several nutrients not included in the analysis for the present study, including vitamin C, carotenoids other than beta-carotene, and various other phytochemicals; they therefore act as a 'proxy' for these beneficial compounds in the present study.

Fruit and vegetables are rich sources of antioxidants, which are known to be protective against cardiovascular disease (Joshi et al. 2001), and also cancer (Weisburger 1991). Childhood intake of fruit and vegetables has also been linked with decreased incidence of cancer in adulthood (Maynard et al. 2003). Since cardiovascular disease is the most common cause of death in Scotland, and cancer the second most common (Scottish Executive 2006), it is of concern that only 2% of the days analysed in the present study met the Government target of five portions per day (Department of Health 2003a).

For fat, SFA and NMES, although the distributions were skewed towards the lower end of the distribution, overall intakes for the study population were still excessively high in health terms. The proportion of days sampled meeting the DRV (ie not exceeding the maximum recommended) was just 49% for fat, 34% for NMES and 33% for SFA intake.

The fact that fewer than half of the sample had acceptably low intakes of fat has implications for the children's weight. Fat is the most calorific nutrient, and when consumed in excess can contribute to obesity, if an individual is insufficiently active (Bray & Popkin 1998).

SFA is equally as calorific as any other form of fat, but has additional negative health implications, making it of particular concern that 77% of the study sample exceeded the DRV. High intakes of SFA are implicated in increased risks of cardiovascular disease (Hu et al. 2001). Although these conditions are traditionally associated with adulthood, initial symptoms are being increasingly seen in children and young adults (Williams et al. 2002).

Only approximately 33% of days analysed had NMES intakes below the maximum value set as the DRV, and this has implications for the children's dental health.

4.1.1) *Comparison with other studies*

Several previous studies have examined nutrient intake in teenage children, and three of these, using similar methodology, and including children of the relevant age range, were selected for closer comparison with the present study, which surveyed 332 children aged 11 – 14 using 5-day estimated intake food diaries.

The NDNS, or National Diet and Nutrition Survey: young people aged 4 – 18 years (Gregory & Lowe 2000) surveyed 475 children in the 11 – 14 age range, using the 7-day weighed intake method. The Department of Health's (DoH) *Diets of British Schoolchildren* report (Department of Health 1989) surveyed 974 children in the 14 – 15 age range, also using the 7-day weighed intake method. The Food Standards Agency Scotland's (FSAS) *Survey of Sugar intake among children in Scotland* (Sheehy, et al. 2008) surveyed 1,461 children in the 3 – 17 age group using food frequency questionnaires followed by interview. Separate results were listed in the report for children aged 3 – 11, and for young people aged 12 - 17. To validate the methodology,

sub-samples of the total sample also carried out either a 4-day estimated intake food diary, or a multiple-sweep 24-hour recall.

It must be noted that the DoH and FSAS reports used samples which included a higher proportion of older children than the present study, and these older children might be expected to have greater food and nutrient intakes. Also, the FSAS study stated the mean intake for consumers of fruit, vegetables and fresh juice, which was used to calculate intake in portions. However, 3% did not consume fruit and vegetables, and 11% did not consume juice, so the mean intake for the whole sample will be lower.

In common with the present study, the comparison studies found excessive intakes of fat, SFA and NMES, and insufficient intakes of micronutrients, with the exception of the DoH study, which found the mean intake of vitamin A to be acceptable. However, the DoH study also found the highest mean energy intake of the studies compared, and a larger food intake could have contributed to the higher vitamin A intake. Also, data on vitamin A intake is generally accepted to require greater caution in interpretation, since more days' data are required to accurately estimate intake (Basiotis et al. 1987).

Although the mean intakes of energy and fat found by the present study were lower than that in the DoH study, they were higher than those for the NDNS and the FSAS study. Despite this higher energy consumption, the micronutrient intakes seen in the present study were often lower than those in the comparison studies, suggesting a lower nutrient density.

The present study found a higher mean SFA intake than all of the other studies. If this is a reflection of changing dietary patterns in children, rather than a characteristic of this particular sample, this could be a matter of public health concern, particularly regarding their risk of cardiovascular disease and some cancers.

The present study's mean NMES intake was lower than that for the NDNS and DoH surveys, but higher than the FSAS study (whose sample also included older children than the present study). However, it must be remembered that the mean intake for all of the studies was higher than the DRV.

The present study found the lowest mean iron intake of all the studies compared, a lower mean vitamin A intake than the NDNS and the DoH study (the FSAS study did not consider this vitamin), and lower than the NDNS for folate (not considered by the other two studies). Once again, if this lower intake is a reflection of a dietary trend over time, this is of public health concern.

Very similar mean NSP intakes were seen in all of the studies compared. The mean calcium intake for the present study was intermediate compared with the higher value found by the FSAS study, and the lower values found by the NDNS and DoH study. It was observed that milk (a calcium-rich food) was popular among children in the present study; it was also noted that the other recent Scottish study (Sheehy et al. 2008) considered also found calcium intakes significantly higher than the earlier, English and UK-wide studies, suggesting that this might be a regional effect. Nonetheless, the fact that almost half of the days (41%) in the present study failed to meet the RNI for calcium suggests that it is UK-wide calcium intakes that are extremely poor, rather than Scottish intakes being particularly high.

The sample in the present sample had a mean daily intake of 1.3 portions (approximately 104g) of fruit and vegetables, which is lower than that of the comparison studies, and also lower than the 2.3 portions recorded in Wrieden's study of 10 – 11-year-old Scottish children (1996). Fruit and vegetables were not popular food choices in the present study; 28% of the days recorded included no fruit or vegetables, and 61% included one portion or fewer.

4.1.2) Variability of nutrient intake

The high standard deviations for some nutrients revealed the large variability in the children's intakes, especially for fruit and vegetable consumption, and vitamin A. The variability of vitamin A has been noted in other studies (Nelson et al. 1989). Other nutrients with notably high variability in the present study were calcium and NMES.

Comparison of the mean and median nutrient intakes also revealed the influence of extreme consumers on the sample mean. This was most notable for nutrients in which the children tended to have low intakes; many of the days sampled had intakes of these nutrients at the low end of the scale, an effect most noticeable for fruit and vegetable intake at lunchtime, when mean intakes were between 0.09 and 0.28 portions, and the median intake was zero.

4.2) Discussion of lunchtime nutrient intake

It is apparent from Figure 4 (percentage of lunches meeting SNSSL) that the mean lunchtime nutrient intakes in the present study rarely met the SNSSL requirements. Only for the following nutrients and lunch types did the mean intakes achieve the SNSSL standards:

- Canteen lunch - fat, SFA and NMES intakes
- Packed lunch - vitamin A intakes

The most extreme failures to meet the SNSSL standards were seen in street lunch NMES and fruit and vegetable intakes, with mean lunchtime NMES intake providing 197% of the SNSSL maximum, and the mean lunchtime fruit and vegetable intake providing only 5% of the SNSSL minimum.

All three lunch types failed to meet the SNSSL for iron by a similar and extensive amount, providing between only 32 – 36% of the SNSSL minimum standard.

Except in the case of NSP and iron, canteen lunches provided the intake closest to reaching the standard, and street lunches the intake furthest from it.

4.2.1) *Canteen lunches – comparison with other studies*

Several other studies on children's canteen lunch nutrient intakes were selected for comparison with the present study, on the basis of similar methodology and age range. However, comparisons are complicated by the fact that the nature of school canteen lunches has changed greatly over time. The most notable changes in recent years have been the introduction of National Nutritional Standards for School lunches in England in 2001 (Department for Education and Skills 2000), and the introduction of the *Scottish Nutrient Standards for School Lunches* (SNSSL) (Scottish Executive 2003b) for secondary schools in Scotland in 2006. Even stricter nutritional standards (Scottish Government 2008b) were brought into force in Scottish secondary schools in 2009 (after the present study was conducted). In Fife, the county where the present study was conducted, these were phased in early, and this was in progress when data was collected.

Therefore, consideration must be made when comparing studies of when they were conducted, and which – if any – nutrient standards were in force.

The comparison studies:

English studies, before nutrient standards:

Study 1: A study of schoolchildren in schools in Kent, England, surveyed in 1968 – 1970 (Cook et al. 1975), analysed the canteen lunches of 264 children in the 13 – 15 age group, using 5-day weighed intake food diaries.

Study 2: A 1972 study of children in a London comprehensive school analysed the lunches of 232 children in the 11 – 18 age group taking canteen lunches (Richardson & Lawson 1972).

Study 3: A study of 11 – 17-year-old children in Cambridge, England conducted between 1977 and 1979 (Nelson & Paul 1983), analysed the canteen lunches of 49 children, using weighed intake food diaries.

Study 4: The Department of Health's *Diets of British Schoolchildren* report (1989) surveyed the canteen lunches of 158 children in the 10 – 14-year age group, using 5-day weighed intake food diaries.

English studies, after standards

Study 5: The *School Meals in Secondary Schools in England* report (Nelson et al. 2004), commissioned for the Food Standards Agency and the Department for Education and Skills, analysed 5,695 canteen meals taken by schoolchildren aged 11 – 17.

Study 6: With a sample closest in age (11 – 12 years) to the present study, research on school lunches in three English secondary schools conducted in 2003 analysed the lunches of 53 children, using 5-day weighed intake food diaries (Gould et al. 2006).

Scottish studies, after standards

Study 7: Most recently, a secondary analysis of the FSAS *Survey of sugar intake among children in Scotland* (McNeill et al. 2009a) surveyed in 2008 the canteen lunches of 27 children in the 12 – 17 age group, using a three-times multiple pass 24-hour recall methodology.

Other confounding factors exist. It must be noted that the older teenagers included in several of the other studies might have different food preferences from the younger children in the present study, and their food (and therefore nutrient) intakes might be greater than those in the present study. Also, modern children's eating patterns have become more disordered, with greater emphasis on snacking and less on formal meals (Cresswell et al. 1983; Anderson et al. 1994; Nielsen et al. 2002; Vereecken et al. 2004; McNeill et al. 2009), suggesting that the lunchtime meal may have been proportionally

larger in earlier studies. This recent emphasis on snacks, and snack foods, will also influence the nutrient composition of children's diets (Hampl et al. 2003).

(Several of the studies with which the present study is compared also considered packed and / or street lunches, which will be examined later in this Discussion. Some of the studies also considered primary school children, which are not considered in this Discussion).

Energy

With the exception of the Department of Health study (Study 4) (1989), which unlike the other studies did not survey younger secondary school children (aged 11 – 13), and showed a higher canteen lunch energy intake, there was a trend towards decreasing energy intake for canteen lunches over time, with the present study falling closest to the other recent studies, with a mean energy intake of 22% below the SNSSL standard. This trend is probably due to the fact that less food is consumed at the lunchtime meal, with more emphasis on snacking (Anderson et al. West 1994).

Fat

In comparison to the earlier studies conducted in England, the fat intake for canteen lunches in the present study were lower, possibly due both to more stringent nutrient standards (the Scottish standards are both food- and nutrient-based, whereas those in England at the time of those studies were food-based). The slightly higher fat intake seen in the other Scottish study, Study 7, (McNeill et al. 2009a), could be due to that study's slightly older age group.

The schools where the present study was conducted were attempting to reduce the fat content of children's canteen meals by using semi-skimmed rather than full-fat milk, low-fat spreads, low-fat rather than 'regular' crisps in packets no larger than 25g, and oven chips rather than fried chips. The schools' requirement that chips must be oven chips went further than the requirements of the SNSSL at the time, which stated that

fried potato products should be served no more than twice per week, and that substituting oven chips was 'desirable'.

SFA

Only two other studies, Studies 5 (Nelson et al. 2004) and 6 (Gould et al. 2006) considered SFA, both conducted in England after the introduction of nutritional standards. Both of these studies found much greater canteen lunch SFA intakes than the present study. This could be due to the stricter nutrient standards now in place in Scotland, in particular in the county of Fife, where the more rigorous standards, only compulsory across Scotland from September 2009, were already beginning to be phased in when the present study was conducted.

The mean SFA content of the canteen lunches in the present study was below the maximum set by the SNSSL, but this difference did not reach statistical significance. However, due to the relatively small energy content of the canteen lunches, when percentage energy from SFA was calculated, the lunches exceeded the SNSSL target by almost half. The SNSSL target is for no more than 11% of energy to come from SFA, while a figure of 14.3% was found for the canteen lunches.

NMES

With the exception of Study 2 (Richardson & Lawson 1972), there appears to have been a trend towards decreasing mean intake of NMES in canteen lunches over time. (The figure for Study 5 (Gould et al. 2006) was for total sugars, rather than NMES, which might explain why it is slightly higher than the trend would suggest, if significant amounts of intrinsic sugars (from milk and fruit) were being consumed).

The schools in which the present study was conducted were attempting to reduce the NMES in children's meals by selling no 'regular' sugar-sweetened soft drinks, and only Lucozade Isotonic (a reduced-calorie soft drink), Ribena light (a reduced-calorie blackcurrant squash), cartons of pure fruit juice, flavoured water (containing low-calorie sweeteners and flavourings), and cartons of semi-skimmed milk. However, pure fruit

juice is relatively high in sugar, and other high-sugar foods (including small chocolate-covered Kit-kat wafer biscuits, 'giant cookies', small bags of mini cookies, and cereal bars, were on sale in the canteen, and were popular choices with the children.

As well as being lower than in the other studies, the intakes of fat, SFA and NMES in the present study – nutrients which have an adverse nutritional impact when consumed in excess – also met the SNSSL standards, by 28%, 4% and 12%. This success was not the case for several of the previous studies, nor indeed for packed and street lunches in the present study.

NSP

All of the studies for which NSP intake was measured showed intakes extremely close to that found by the present study, with the exception of the School Meals in Secondary Schools in England report, Study 5 (Nelson et al. 2004), which found a higher intake. All fell short of the minimum set by the SNSSL, with the present study showing a 42% shortfall.

Although the schools in which the present study was conducted were attempting to increase children's lunchtime fibre intake by providing fruit, and wholemeal as well as white bread sandwiches, these were not popular choices. Although food choices were not analysed in the present study, it was observed that sandwiches consumed as part of canteen lunches were almost exclusively made from white bread.

Vitamin A

The mean canteen lunch vitamin A intake in the present study was lower than that in the FSAS study, Study 7 (McNeill et al. 2009a), but higher than the two earlier English studies that considered this nutrient: Study 4 (Department of Health 1989) and Study 5 (Nelson et al. 2004). Every study found canteen lunch intakes below the SNSSL standard, with the present study finding a value 30% below the SNSSL minimum.

Folate

The canteen lunch folate intake found by the present study was intermediate when compared with the other three studies analysing this nutrient (Nelson et al. 2004; Gould et al. 2006; McNeill et al. 2009a). None of the studies found an intake that would have met the SNSSL standard, with the present study finding a shortfall of 37%.

Folate is one of the nutrients highlighted by the SNSSL as being particularly important to supply in school meals, due to its nutritional importance. For this reason, the SNSSL in place during the current study (Scottish Executive 2003b) stated that a canteen meal should provide 40% of a child's RNI, a higher percentage than that for several other nutrients in the standards. It is therefore a matter of concern that none of the studies, the present study included, found a mean canteen lunch folate intake that met the standard, and that the intake found by the present study was so deficient.

The SNSSL lists and recommends high-folate foods including Brussels sprouts, black-eye beans, liver, green vegetables, cauliflower and peas. However, aside from very occasional mentions of cauliflower cheese, none of the food diaries for canteen meals in the present study included any of the high-folate foods listed.

Calcium

Other than Study 4, the *Diets of British Schoolchildren* report (Department of Health 1989), with its older sample and larger energy intake, the present study found the highest calcium intake of the studies compared, including the more recent Scottish study, also completed after the introduction of the SNSSL standards, and which also included older children. It was noted during the nutrient analysis for the present study that small cartons of semi-skimmed milk, and sandwiches containing cheese, were relatively popular canteen choices. However, the calcium intake for the present study was nonetheless 32% below the minimum set by the SNSSL.

The importance of calcium in children's diet is recognized by the SNSSL, in that the lunchtime requirement is set higher than that for some of the other nutrients, at 35% of the RNI. The Standards also list and recommend high-calcium foods and drinks, but only milk, cheese and bread featured regularly in the canteen lunch choices for the present study. It is expected that the other recommended foods – for example tofu, tinned fish where the bones are eaten, beans and lentils – were not served due to the expectation that they would not be eaten by the children.

Iron

The present study, and the two other most recent studies, Study 6 (Gould et al. 2006) and Study 7 (McNeill et al. 2009a) found canteen lunch iron intakes that were much lower than in previous studies, and 64% below the minimum set by the SNSSL. The earliest study (Cook et al. 1975), completed 38 years before the present study, found a 2.4 times greater mean canteen lunch iron intake. If this reflects a decrease in the iron content of canteen lunches over time, and this trend is also seen in children's total diets, there could be implications for children's health. Teenagers have particularly high iron requirements, due largely to growth (particularly in boys) and the beginning of menstruation in girls, and low iron intakes will increase children's risk of iron deficiency anaemia (Nelson et al. 1993).

Along with calcium, folate, and vitamin C, iron is highlighted in the SNSSL as a nutrient of particular importance, with the standard set higher than that for other nutrients, at 40% of the RNI in the case of iron in the version of the SNSSL in place at the time of the present study (Scottish Executive 2003b). The SNSSL lists and recommends high-iron foods including lean beef, lamb, pork, mince, burgers, liver, chicken or turkey (especially dark meat), liver, canned oily fish, and vegetarian sources such as pulses. However, meat products were only very rarely on the menu at the schools in the present study (in the form of roasts, lasagna and curry), and were chosen only rarely. Ham sandwiches and rolls were sometimes chosen, but were not as popular as cheese, tuna mayonnaise, or chicken. None of the food diaries included pulses in the canteen lunch meal.

Fruit and vegetables

Study 4, the Department of Health study (1989) measured median fruit and vegetable intake, plus the mean calculated from the proportion of the children who did consume these foods (and not the whole sample). Therefore this data was not comparable with the results from the present study.

Study 7, the secondary analysis of the FSAS report (McNeill et al. 2009a) measured fruit and vegetable intake in grams for lunches and over the whole day, so these were converted to portions for comparison with the present study. The FSAS report found a lower intake than that in the present study. Both fell far short of the SNSSL target, with the mean intake found by the present study achieving only 14% of the SNSSL target, and only 3.6% of canteen lunches meeting the target.

The SNSSL notes that “habitually low consumption of fruits and vegetables remains one of the most damaging features of the Scottish diet”, and states that the menu should provide a choice of at least two vegetables and two fruits, plus fruit juice, and this did occur in the schools where the present study was conducted. However, no food diaries included cooked vegetables in the canteen lunch, and very few included fresh fruit, pure fruit juice, or salad or fruit salad boxes. (If fruit juice was consumed during lunch, one portion (but no more however much was consumed) was counted in the analysis for the present study. If fruit juice was consumed at lunchtime and also other times of day, the lunch portion was the serving included in the analysis.)

Most of the fruit and vegetables consumed as part of canteen lunches came from fresh fruit, and from salad in sandwiches and baguettes. It was noted that most but not all sandwiches included salad, and the presence of salad appeared not to influence the children’s choices.

In summary

In comparison with previous research, the canteen lunches in the present study were lower in fat, SFA and NMES, and met the SNSSL targets for these macronutrients. In comparison with the other studies, they contained less vitamin A, folate and fruit and

vegetables. Canteen lunches in the present study were higher in calcium and fruit and vegetables than the comparison studies (though still below the SNSSL minimum, by 86% in the case of fruit and vegetables). They were also lowest in iron, the micronutrient for which these canteen lunches showed the greatest shortfall when compared to the SNSSL.

When compared with the other lunch types in the present study, canteen lunches had the lowest energy, fat, SFA and NMES contents, as well as the lowest percentages of energy from fat and NMES.

4.2.2) Packed lunches – comparison with other studies

Of the three lunch types, packed lunches had the highest contents of SFA, vitamin A, and fruit and vegetables.

While there have been public health initiatives encouraging parents to provide healthier packed lunches, there is no legislation governing this area, so any trends over time might be expected to correspond to trends in overall diet, or (if positive), possibly growing awareness among parents of the importance of healthy packed lunches.

Although there are no nutritional standards set for packed lunches, their nutrient content was compared with the SNSSL standards, which were used as a yardstick for 'nutritional quality'.

Comparison studies:

Study 1: The Department of Health's *Diets of British Schoolchildren* report (1989) surveyed lunches including the packed lunches of 226 children in the 10 – 14-year age group, using 5-day weighed intake food diaries.

Study 2: The Food Standards Agency's *School Lunchbox Survey* (Jefferson & Cowbrough 2004) analysed the packed lunches of 544 children aged 10 – 11.

Study 3: A secondary analysis of the FSAS *Survey of sugar intake among children in Scotland* (McNeill et al. 2009a) surveyed children's lunchtime meals, including the packed lunches of 14 children in the 12 – 17 age group, using a three-times multiple pass 24-hour recall methodology.

Energy

As with canteen lunches, the earlier studies found greater mean energy intakes for the packed lunches surveyed in earlier studies. The present study found the lowest intake, at a mean value of 14% below the SNSSL standard set for canteen meals.

Fat

In common with the situation seen in canteen lunches, and in packed lunches for energy intake, there was a trend towards decreasing fat intake over time. However, despite this encouraging trend, the present study exceeded the maximum set by the SNSSL by 4%.

This was in contrast to the canteen lunches in the present study, which met the standard, and the street lunches, which exceeded them by a greater amount.

SFA

Only one other study, Study 2 (Jefferson & Cowbrough 2004), measured SFA intake, finding a packed lunch intake slightly lower than the present study, whose intake was 149% of the SNSSL maximum. The large amounts and frequency of cheese sandwiches in these packed lunches could have contributed towards this excess.

In the present study, packed lunches were the lunch option which showed the greatest intake of SFA, as well as the greatest percentage of energy from SFA (14.3%).

NMES

The present study found a higher NMES intake from packed lunches than the other study measuring this nutrient, Study 3 (McNeill et al. 2009a), despite the other study also taking place recently in Scotland, and including older children with higher energy intakes. Both studies found mean NMES intakes exceeding the maximum set by the SNSSL for canteen lunches, with the present study's packed lunches providing 137% of the standard. Many of these packed lunches included chocolate in the form of chocolate-coated confectionary (for example Mars bars, Twix), biscuits (for example, jaffa cakes and packets of 'mini cookies'). Also, unlike canteen lunches, packed lunches often included 'regular' (ie sugar-sweetened), rather than low-sugar or 'diet' versions of soft drinks.

The figures in the present study for the mean intake of NMES (24.7g) and percentage of energy from NMES (17.6%) were intermediate between those found for canteen and street lunches. This is possibly due to the fact that children have a liking for high-sugar foods, and the greater the availability and the more choice they are allowed to exercise the more sugary foods they are likely to consume. Canteen lunches are the option with the least availability of sugary foods; packed lunches are not governed by nutrient standards, but parents may choose or influence their contents, and children eating street lunches have a free choice from an easily available and wide range of sugary foods.

NSP

The present study found a lower NSP intake than the other study measuring this nutrient, Study 3 (McNeill et al. 2009a), which may be due to the other study including older children with larger food intakes. Both studies found intakes below the SNSSL, with the present study showing a shortfall of 50%.

Vitamin A

The packed lunch vitamin A intake found by the present study was higher than the most recent and comparable other study, Study 3 (McNeill et al. 2009a), but lower than the earliest, Study 1 (Department of Health 1989). The large variability seen between studies could be due to the difficulty in measuring vitamin A intake using a limited number of days' data (Basiotis et al. 1987).

The packed lunch vitamin A intake for the present study provided 109% of the SNSSL standard, the only lunch type in the present study to meet the standard. This is likely to be due to fruit provided in packed lunches, and the use of fortified spreads in sandwiches.

Folate

Only one other study, Study 3 (McNeill et al. 2009a) measured packed lunch folate intake, and this found a higher intake than the present study, possibly due to the comparison study's older sample with greater food consumption. Both studies found intakes far below the SNSSL target, with a 50% shortfall seen in the present study. This was intermediate between the results obtained for canteen and street lunches in the present study.

Calcium

The mean packed lunch calcium intake found by the present study were only half those seen in the most recent and comparable study, Study 3 (McNeill et al. 2009a), and an even lower proportion of the value seen in the other study measuring this nutrient, Study 1 (Department of Health 1989). Although the packed lunches in the present study were observed to be high in cheese (a calcium-rich food), they lacked the milk consumed in the canteen lunches, which could explain the fact that although the packed lunches were high in SFA, they were relatively low in calcium, with an intake of 73% of the SNSSL minimum.

Iron

The earliest of the comparison studies, Study 1 (Department of Health 1989) found a much higher lunchtime iron intake than the other two studies (including the present study) that measured this nutrient. The other comparable study, Study 3 (McNeill et al. 2009a) found an iron intake closer to, but still higher than, the present study, although this could be partly due to the larger food intake of its older sample. All of the studies, including the early study, failed to meet the SNSSL standard for iron. The shortfall of iron in packed lunches in the present study was the greatest shown by any of the nutrients analysed, with an intake 42% of the SNSSL.

Fruit and vegetables

Only one other study, Study 3 (McNeill et al. 2009a) measured the content of fruit and vegetables in packed lunches, and found slightly higher intakes than the present study. Both studies found packed lunch intakes that, while higher than those for canteen or street lunches, were far below the SNSSL standard, with an intake 24% of the standard in the present study.

In summary

The present study found lower packed lunch intakes of energy and total fat than previous studies, and higher intakes of SFA and NMES than previous studies. For fat, SFA and NMES the present study exceeded the maximum set by the SNSSL, especially in the cases of SFA and NMES. Intakes of vitamin A, folate, calcium, iron, and fruit and vegetables, were lower in the present study than previous studies, and only met the SNSSL standard in the case of vitamin A, probably due to the relatively fruit and vegetable intake of the packed lunches, and the inclusion of fortified spreads in sandwiches.

Packed lunches had the highest intakes of SFA, and percentage of energy from NMES, of the three lunch types in the present study. Their fat content and NMES contents were intermediate between that of canteen and street lunches. The packed lunches had the highest vitamin A and fruit and vegetable contents of the lunch types, and the lowest

NSP and iron contents. Their folate and calcium contents were intermediate between those for canteen and street lunches.

4.2.3) *Street lunches – comparison with other studies*

Results from the present study were compared with three other studies analysing nutrient intake for street lunches.

Study 1: The Department of Health's *Diets of British Schoolchildren* report (1989) surveyed lunches including the street lunches of 122 children in the 10 – 14-year age group, using 5-day weighed intake food diaries.

Study 2: The author of the present study (Norris 2005) conducted a survey of the street lunches of 24 children aged 12 - 13, using 4-day estimated intake food diaries.

Study 3: Study 3: A secondary analysis of the FSAS *Survey of sugar intake among children in Scotland* (McNeill et al. 2009a) surveyed children's lunchtime meals, including the packed lunches of 38 children in the 12 – 17 age group, using a three-times multiple pass 24-hour recall methodology.

Energy

In contrast to the other recent study conducted in Scotland, Study 3 (McNeill et al. 2009a), but in common with the previous studies, the present study found the street lunch energy intake to exceed the SNSSL target (providing 109% in the present study). This was the greatest excess found among the three lunch types in the present study.

Fat

The street lunch fat intake found by the present study was similar to that in Study 1, the *Diets of British Schoolchildren* report (Department of Health 1989), and higher than that found by the other studies. All of the studies, with the exception of the other recent Scottish study, Study 3 (McNeill et al. 2009a), found street lunch fat intakes exceeding the SNSSL maximum, providing 128% in the case of the present study.

Street lunches were higher in fat than the canteen and packed lunches in the present study (though packed lunches showed a higher percentage of energy from fat). It was noted that children consuming street lunches in the present study often chose high-fat foods, such as chips, sausage rolls, bridies (meat pasties), crisps, doughnuts, and high-fat Chinese dishes from a nearby Chinese takeaway. Unlike those provided in the school canteens, the chips were fried, and the crisps were not low-fat, and often sold in larger packets.

SFA

Only one other study, Study 2 (Norris 2005) analysed SFA, and found a much lower intake for street lunches than the present study. The mean SFA intake for the present study provided 137% of the SNSSL maximum.

The street lunches in the present study had an SFA content higher than the canteen lunches, and slightly lower than the packed lunches (though this difference was not significant). It was noted that the street lunches were high in meat products rich in SFA, such as sausage rolls, bridies (meat pasties) and beef burgers.

NMES

Although lower than that for the other comparison studies, the street lunch NMES intake found by the present study provided 197% of the maximum set by the SNSSL. This was the largest nutrient excess found for street lunches in the present study.

Street lunches were significantly higher in NMES (and also percentage energy from NMES, with a value of 19.8%, or nearly double the SNSSL target), than canteen and packed lunches in the present study.

NSP

The street lunch NSP intake for the present study was lower than that for the other studies, providing 54% of the SNSSL minimum.

Of the three lunch types in the present study, street lunches had a mean NSP intake intermediate between that of canteen and packed lunches. However, the difference between street lunches and either of these other lunch types was not statistically significant.

Vitamin A

The vitamin A intakes found by the studies varied greatly, probably at least partly due to the difficulty in accurately measuring intake of this vitamin using a limited number of days (Basiotis et al. 1987). The street lunch intake in the present study was intermediate between the other studies, and provided 52% of the minimum set by the SNSSL.

In the present study, street lunches provided significantly less vitamin A than canteen or packed lunches.

Folate

The folate intake found in the present study was close to the smaller Scottish study, Study 2 (Norris 2005) which surveyed a similar age group; the mean intake in the present study provided 37% of the minimum set by the SNSSL. The other study measuring this nutrient, Study 3 (McNeill et al. 2009a) found a higher intake, possibly partly due to the older children (with greater food intakes) in this comparison study.

Folate contents of street lunches were lower than those of canteen or packed lunches in the present study.

Calcium

The street lunch calcium intake in the present study was close to that of the other studies, and provided 51% of the minimum set by the SNSSL.

Street lunches contained less calcium than the canteen or packed lunches in the present study. Although cheese was a popular ingredient in the choices of children

consuming street lunches, none of their food diaries mentioned other dairy products such as milk or yogurt.

Iron

The street lunch iron intake found in the earliest study, Study 1 (Department of Health 1989) was almost double that of the present study, which found the lowest intake of any of the comparison studies, and provided 44% of the minimum set by the SNSSL.

The iron contents of the three lunch types in the present study were close, and the only difference reaching statistical significance ($p < 0.05$) was that between canteen lunches (highest content) and street lunches (lowest content). It was also noted that low iron intakes were a characteristic of children in the present study.

Fruit and vegetables

Only two other studies examined the fruit and vegetable content of street lunches, Study 2 (Norris 2005) and Study 3 (McNeill et al. 2009a), and both were conducted recently in Scotland. All three studies found street lunch fruit and vegetable intakes seriously below the SNSSL target of two portions, with by far the lowest amount found in the present study, with a mean street lunch intake of 0.09 portions, just 5% of the minimum set by the SNSSL.

Of the three lunch types in the present study, street lunches had by far the lowest fruit and vegetable content, and 90% of the street lunches contained no fruit or vegetables. Only 0.7% of the street lunches met the SNSSL target of 2 portions.

In summary

Unlike the situation for canteen and packed lunches, the energy intake for street lunches in the present study exceeded the SNSSL target. Compared with the other studies measuring fat and SFA, the street lunch intake was high, and exceeded the SNSSL. Regarding NMES, the present study found lower intakes than the comparison studies, though still exceeding the SNSSL maximum by 97%. For all micronutrients, the

street lunch intake in the present study fell far short of the SNSSL minimums, most severely for iron, providing only 45% of the SNSSL minimum. For street lunch fruit and vegetable intake, the present study found the most severe deficiency of any of the studies, with a mean intake just 5% of the SNSSL minimum.

Canteen lunches provided the most nutritionally beneficial intake of fat, SFA, NMES, NSP, folate, calcium and iron (highest in these macronutrients; lowest in NSP and these micronutrients). Although packed lunches had the highest SFA content, they were also highest in vitamin A and fruit and vegetables. Street lunches were the most nutritionally poor lunch option in almost all cases.

4.3) Lunchtime energy intake and eating patterns

There were statistically significant differences between the energy content of each of the lunch types in the present study. There were also significant differences between each lunch type and the SNSSL. Street lunches provided 122% of the SNSSL, and since many of the foods consumed were low in NSP and micronutrients, and high in fat, SFA and sugar, these extra calories would not make a positive contribution to children's health. The energy content of packed lunches was 86% of the standard, and that of canteen lunches 78% of the standard.

4.4) Lunchtime nutrient density

In terms of children's health, although the actual quantities of nutrients that children consume are more important, the nutrient density of the food they consume is also relevant.

Especially in view of the disordered eating patterns observed in the present study, and the fact that they are easily distracted from eating by activities such as socializing (Norris 2005), children should be encouraged to consume foods high in micronutrients,

and with low densities for fat, SFA and NMES. By contrast, preferentially eating foods of poor nutrient value can decrease children's appetite for more nutritious foods.

When compared with the SNSSL lunchtime energy target of 646kcal, the mean energy intake for packed lunches (556kcal) and especially canteen lunches (504kcal) was less than the standard. The comparatively higher energy value of street lunches could be due solely to the children's consumption of larger quantities of food, to consumption of a higher-fat lunch (fat being the most calorific nutrient, at 9kcal/g compared with 4kcal/g for carbohydrates or protein), or to a combination of the two factors.

While street lunches were found to contain the most fat (based on the mean intake value), packed lunches had the highest nutrient density for fat, indicating that for street lunches at least part of street lunches' 'fattiness' was due to the quantity of food eaten, rather than the children consuming more high-fat foods.

Regarding micronutrients, looking at lunchtime intakes alone (without the information provided by nutrient densities) might produce a more favourable picture of street lunches than is justified. The larger quantities of food consumed in street lunches make it easier to achieve higher nutrient intakes.

Fat

Regarding intake, street lunches contained the most fat, followed by packed lunches, with canteen lunches providing the least. However, in terms of nutrient density for fat, the difference between packed and street lunches was not statistically significant, suggesting that street lunches were not richer in fat than street lunches, and simply larger.

SFA

While the amount of SFA in street lunches was much higher than in canteen lunches, the difference in SFA density between the two lunch types was not statistically significant. This indicates that the nutritional quality of the two lunches as regards SFA

was not significantly different, but that the larger amounts consumed by children eating street lunches led to their consuming more SFA.

NMES

Canteen lunches contained significantly less NMES than packed or street lunches, and their nutrient density for NMES were also significantly lower. However, while packed lunches contained significantly less NMES than street lunches, their nutrient density was not significantly different, suggesting that street lunches are not solely high in NMES because they are particularly rich in NMES, but also due to the amount of food consumed.

NSP

The difference in the amount of NSP consumed as part of canteen, packed and street lunches was not statistically significant. However, the nutrient density for NSP seen in canteen lunches was significantly higher than that for packed or street lunches ($p < 0.001$), suggesting that foods richer in NSP were being consumed as part of canteen lunches.

Vitamin A

Regarding intake, packed lunches provided the most vitamin A, followed by canteen lunches, with street lunches providing the least; the differences in vitamin A content between the groups was significantly different. However, the level of significance for the intake of vitamin A between packed (the greatest amount) and canteen lunches (the intermediate amount) was of a greater significance level than the difference in vitamin A density between the two groups. This suggests that at least some of the benefit of the packed lunches' vitamin A content is due to their larger size, rather than the extent to which they are denser in this nutrient than canteen lunches.

Folate

Canteen lunches had the highest folate intake, followed by packed lunches, with street lunches providing the least – the differences between each group were statistically significant ($p < 0.001$). This was the identical situation to that for lunchtime nutrient density for folate.

Calcium

Regarding intake, street lunches contained significantly less calcium than packed or canteen lunches. However, although canteen lunches did not contain significantly more calcium than packed lunches, their nutrient density for this mineral was significantly higher. This suggests that if children consuming canteen lunches could be encouraged to eat larger lunches, and the nutrient composition remained unchanged, their calcium intake could be boosted.

Iron

Regarding intake, canteen lunches contained significantly more iron than packed or street lunches, but the difference in iron content between street and packed lunches was not significant. However, the nutrient density for iron was significantly greater ($p < 0.001$) for packed lunches than street lunches, suggesting that children consuming street lunches were eating larger quantities of iron-poor foods.

Fruit and vegetables

Regarding intake, packed lunches contained the most fruit and vegetables, followed by canteen lunches, with street lunches containing the least; the differences between each group were significantly different ($p < 0.001$). However, when fruit and vegetable density was examined, the difference between packed and canteen lunches was not statistically significant. Also, the amount of fruit and vegetables consumed by all of the children was extremely low. This suggests that packed lunches are no richer in fruit and vegetables (per calorie consumed) – the children could be simply eating more food.

4.4.1) Lunchtime nutrient density – effect on ranking of lunch types

Another point to consider is that the greater amounts of food consumed in street lunches boosted those days' intakes for several nutrients, notably NSP and vitamin A, folate, calcium and iron. However, this was not enough to change the nutritional ranking of street lunches as the least nutritious option.

When lunchtime nutrient densities for fat, SFA and NMES were considered, the ranking changed from that for nutrient intakes. For fat and SFA, packed lunches (with their lower calorie content) showed a higher percentage of fat and SFA calories (nutrient density) in the meals than street lunches. It was noted that many of the packed lunches contained cheese and processed meats, which could at least partially account for this.

The large quantities of food consumed in street lunches also led to the consumption of high intakes of fat, SFA and NMES. Compounding this effect, many foods consumed during street lunches (for example sausage rolls, doughnuts, deep fried chips, and sugar-sweetened beverages) were high in these macronutrients.

Regarding NMES, street lunches showed the least favourable nutrient profile in terms of both the excessive quantity consumed, and the percentage of lunchtime calories contributed by NMES (a higher proportion than for packed or canteen lunches).

The findings above emphasise the importance in canteen lunches in terms of nutritional quality as well as quantity, especially in terms of NSP and calcium.

4.5) Total daily intake – comparison with DRVs

Although the lunchtime meal is undeniably an important part of the total food intake, it is the total daily diet that affects children's health, both now and in the future.

Considerable resources have been invested in improving the nutritional quality of school meals (canteen lunches), and increasing their uptake. However, if children eating packed lunches, which are nutritionally inferior in some respects (for example regarding their high SFA content), and street lunches, which have been found to be nutritionally poor, compensate by eating healthier food outside the school lunchtime, their total daily intakes could still be acceptable. If this were the case, it might be argued that investing resources into canteen lunches is not cost effective, and resources might better be allocated towards more general public health policy focusing on improving other aspects of children's diets. However, if street lunch days achieved acceptable nutrient intakes, but canteen lunch days were significantly better, it would still be advantageous to invest in school meals.

For these reasons, the present study analysed each day's total nutrient intake as well as the lunchtime intake, to determine whether 'canteen lunch days' were nutritionally superior to 'packed lunch days' or 'street lunch days'.

In the present study, the nutrient density provided by the various lunch types, and the days including them, was also compared with the nutrient density of a hypothetical lunch meeting the SNSSL, and a hypothetical day meeting the DRVs for the various nutrients considered. It was found that the actual nutrient densities tended to be much closer to the ideal (hypothetical) nutrient density for the whole day than for lunchtime. This suggests that achieving the lunch standards is more difficult than reaching the Dietary Reference Value for the whole day.

Energy

When mean total daily energy intake was examined, total daily intake for days including all three lunch types were proportionally closer to the EAR, than the lunchtime energy intakes were to the SNSSL target. The mean total daily energy intake for each lunch type was within 10 percent of the EAR (canteen and packed lunch days being slightly lower, and street lunch days slightly higher).

Fat

Regarding fat, the mean intake for only canteen lunch days met the DRV (mean fat intake = 94% of DRV), and street and packed lunch days contained significantly more than the DRV (means = 109% and 119% of the DRV, respectively).

At the end of the day, significant differences remained between the fat intakes recorded on days when canteen, packed and street lunches were eaten.

SFA and NMES

For SFA and NMES, all days (regardless of lunch type) significantly exceeded the maximum set by the DRV.

Greater excesses were seen for NMES intake than SFA intake, and in each case street lunch days contained the largest quantities of these macronutrients, and canteen lunches the least.

When the nutrient density for SFA was calculated, days containing canteen, packed and street lunches were much closer to one another, and the difference between percentage energy from SFA for canteen and street lunch days (the days with the lowest SFA percentages) was not significant.

Regarding NMES, at the end of the day, the difference between the NMES density of packed and street lunch days was not significant. However, canteen lunch days were

proportionally less rich in NMES than packed lunch days or street lunch days, and these differences were statistically significant, suggesting that the nutritional advantage provided by having a canteen lunch (as far as NMES intake and density are concerned) remains when the total daily diet is considered.

NSP, micronutrients and fruit and vegetables

Regarding mean intakes of NSP and micronutrients, no days reached the minimum set for the RNI (regardless of lunch type). Mean daily intake values for vitamin A intake on packed lunch days (99% of RNI), folate and calcium intake on canteen lunch days (95%), and folate intake on packed lunch days (95%) came closest to meeting the RNI (values in brackets represent percentage of RNI achieved).

For mean iron intake, no days (regardless of lunch type) exceeded 75 percent of the minimum set for the DRV, and no days exceeded 62 percent of the minimum set for the DRV for NSP.

The greatest deficiencies were seen for fruit and vegetable intake, with the highest mean intake, seen on packed lunch days, being just 36% of the Government target, and the lowest mean intake, on packed lunch days, just 18% of the target.

4.5.1) Percentage of days meeting the DRV

Examining the percentage of days (categorized by whether they included a canteen, packed or street lunch) enabled determination of whether any lunch type provided nutritional benefit (or was detrimental) to a greater proportion of the population.

When the percentage of days' nutrient intake meeting the DRVs was examined for canteen, packed and street lunches, the situation appeared to be of even greater nutritional relevance than when mean intakes were considered. This suggested that some 'super-consumers' or 'under-consumers' could have been skewing the mean data so that the overall nutritional picture obtained appeared more favourable than when the

number of children affected by potentially detrimental high or low intakes of nutrients were considered.

Regarding proportions of days meeting micronutrient targets, more canteen lunch days met the DRVs than packed, and especially street, lunch days (with the exception of NSP, vitamin A and iron intakes, for which more packed lunch days met the target). In the cases of NSP and vitamin A, this effect was probably due to the higher intake of these nutrients in the packed lunches, rather than in the nature of food consumed at other times of day. For all nutrients, street lunch days were the category with fewest days meeting the DRVs (with the exception of SFA and energy from SFA, for which packed lunch days were the category where fewest days met the target).

As with mean intakes, the nutrients and foods of greatest concern were NSP, iron, and fruit and vegetables.

The proportion of days meeting the RNI (the intake adequate for 97.5% of the population) for iron intake, ranged from 18.8% of days surveyed (packed lunch days) to 15% (canteen lunch days). Of great concern is the fact that only 73.3 – 77.5% of days (depending on lunch type) met the LRNI for iron. The LRNI is the nutrient intake judged sufficient for just 2.5 percent of the population (those with particularly low requirements), so it would be expected and desired that the vast majority of days surveyed would reach this value.

For NSP an even smaller proportion of the days recorded met the DRV. Proportions of days surveyed meeting the RNI ranged from 9.4% for packed lunch days, to just 5% for street lunch days (an intermediate proportion of canteen lunch days met the DRV). The percentage meeting the LRNI for NSP ranged between 35.9 – 38.2%.

Fruit and vegetable intake was the area of most serious concern when proportions of the study population meeting the Government target were considered. Not one of the 404 street lunch days analysed in the present study met the target of five portions in a day. Only 2.5% of canteen lunch days, and 5.5% of packed lunch days, met the target.

4.5.2) Contribution of lunch intake towards total daily intake

By comparing lunchtime intake with total intake over the whole day, it was possible to calculate each lunch type's contribution towards overall nutrient intake, and therefore its importance in the daily diet. If, for example, canteen lunches provided a very high contribution towards children's total intake of a beneficial nutrient, this would be another argument in favour of the consumption of school meals. If, however, canteen lunches were not providing the expected and desired contribution towards a particular intake of beneficial nutrients, or provided a particularly high proportion of a child's intake of fat, SFA or NMES, this could be highlighted as an area to address, possibly by changes to canteen menus.

In terms of energy, fat, SFA and NMES, street lunches contributed a larger proportion of total intake than canteen and packed lunches, indicating that they were poorer in dietary quality with respect to fat, SFA and NMES, and made a negative contribution to a healthy diet. An exception to street lunches being the least healthy option was the proportion of SFA intake contributed by packed lunches, which was higher than that provided by the other lunch types. For fat, SFA and NMES, canteen lunches provided the lowest proportion of total intake, indicating the most beneficial contribution towards the total dietary quality regarding these nutrients.

Regarding NSP and micronutrients, canteen lunches contributed a greater proportion of the total intake than packed or street lunches, with street lunches contributing the least. Packed lunches provided the greatest contribution towards total vitamin A intake of the three lunch types.

With very few exceptions (such as street lunch energy and fat content, and packed lunch vitamin A intake), none of the lunch types provided the 'expected' approximately one-third of intake for any nutrient, and instead provided percentages below this proportion. This is probably at least partly due to lunches making a smaller contribution to the total day's food intake, due to the disordered eating patterns exhibited by the

children, with snacking contributing a particularly high proportion of the food consumed, and less food being consumed at traditional meal times, including lunchtime.

Canteen and packed lunches provided similar proportions of daily energy intake (27% and 28% respectively), with street lunches providing the highest proportion (33%). When fat, SFA and NMES were considered, this canteen lunches also provided the lowest proportion of daily intake, and street lunches the highest proportion. In the case of street lunches, the proportion of NMES consumed at lunchtime was 38%, above the 'expected' 33%.

Regarding NSP, canteen lunches provided the greatest percentage contribution to daily intake (28%), followed by street lunches (26%) and packed lunches (23%). Street lunches' greater contribution than packed lunches' was due to the larger amount of food consumed, rather than NSP density.

The children obtained a low proportion of their total micronutrient intake from their lunchtime meal. The micronutrient for which lunch appears to be most important was vitamin A in packed lunches. Although packed lunches also made the greatest percentage contribution to fruit and vegetable intake of the three lunch types, this figure was still very low (27%). Canteen and street lunches provided only 20% and 10% respectively of daily fruit and vegetable consumption.

Canteen lunches were the most important sources of folate, calcium and iron, with street lunches providing the least contribution towards daily intakes of these micronutrients.

4.6) Lunchtime contribution towards total nutrient intake – comparison with other studies

Study 1: A study of 11 – 17-year-old children in Cambridge, England conducted between 1977 and 1979 (Nelson & Paul 1983), analysed the canteen lunches of 49 children, using weighed intake food diaries.

Study 2: The Department of Health's *Diets of British Schoolchildren* report (Department of Health 1989) surveyed the canteen lunches of 158 children in the 10 – 14-year age group, using 5-day weighed intake food diaries.

Study 3: A secondary analysis of the FSAS *Survey of sugar intake among children in Scotland* (McNeill et al. 2009a) surveyed children's lunchtime meals, including the packed lunches of 38 children in the 12 – 17 age group, using a three-times multiple pass 24-hour recall methodology.

The present study found canteen lunches to provide a lower proportion of daily intake (27%) than packed lunches (28%) or street lunches (33%). This was the same ranking of energy intakes seen in the other studies (Nelson's study did not include street lunches). In all but the earliest study, Study 1 (Nelson & Paul 1983), although lunchtime energy intake generally provided the expected proportion of approximately one-third of total daily intake (with a slightly lower proportion, similar to that in the present study, seen in Study 3 (McNeill et al. 2009a), many lunches did not provide the expected approximately one-third of daily intake of individual nutrients.

Interesting differences were noted between the contribution towards total nutrition provided by canteen lunches seen in studies conducted before and after the introduction of nutrient standards.

Two studies – one from the 1970s, Study 1 (Nelson & Paul 1983), and another from 1983, Study 2 (Department of Health 1989) were conducted before nutritional standards in schools. The more recent Scottish study, Study 3 (McNeill et al. 2009a) and the present study, were both conducted after the introduction of the food-based and nutrient-based school meal standards in Scotland (Scottish Executive 2003b). While in one of the earlier studies, Study 2 (Department of Health 1989), canteen lunches made a larger contribution towards children's intakes of fat, SFA and NMES, this situation was reversed in the very earliest, and also the most recent studies, when canteen lunches had much less of a negative impact on children's overall intakes of these macronutrients. It appears that during a period beginning approximately covering the

early 1980s, canteen meals went through a phase when they were nutritionally very poor.

However, during this time canteen meals did make a larger contribution towards children's intakes of calcium and iron than they do currently. It is possible that school meals consumed then were richer in foods such as red meat and dairy products, which are high in these minerals.

When vitamin A and folate are considered, it was the modern Scottish school meals in Study 3 (McNeill et al. 2009a) and the present study that provided the greatest contribution, possibly due to the introduction of the new standards in Scotland (Scottish Executive 2003b). It is possible, also, that the greater relative importance of canteen meals for these nutrients is also partly due to a decrease in consumption of vitamin A and folate-rich foods at times other than lunchtime.

In both modern Scottish studies (Study 3 and the present study), it was packed lunches that made the most important contribution towards children's total fruit and vegetable intake, and street lunches the least. However, the present study found canteen lunches to be a more important source, and street lunches a less important source, than McNeill's secondary analysis of the FSAS Sugar Study (Study 3) (McNeill et al. 2009a).

Nutritional improvements to canteen food are also apparent over time. Cook's study conducted in 1968 – 1970 (Cook et al. 1975) found that a canteen lunch provided a higher proportion of daily nutrient intake than the other lunch options available. However, a study conducted approximately 10 years later (Nelson & Paul 1983) asserted that the nutritional quality of canteen lunches had deteriorated since the time of Cook's study. The worsening nutritional quality of canteen food was reiterated (Nelson et al. 2007b), in a secondary analysis of the NDNS, and its comparison with data collected in 2004 (three years previously). Canteen food was found to be less healthy than that consumed over the rest of the day and the authors concluded that the introduction of food-based nutrient standards in England in 2001 had not improved children's canteen lunch food choices. Because foods high in fat, sugar and salt

remained on the menu, and these were the foods preferred and chosen by the children, their nutrient intakes were correspondingly not conducive to good health.

However, it appears that time, and the introduction of new food- and nutrient-based school meals standards in Scotland, have changed the situation once more. The present study, conducted in Scotland four years after the previous reference, and after significant improvements to canteen meals, found canteen food to be healthier than that eaten at other times of day. In the present study, it was street lunches that were so nutritionally poor that dietary shortfalls and excesses could not be compensated for by other meals. The FSAS secondary analysis of the Survey of sugar intake among children in Scotland (McNeill et al. 2009a) also found canteen meals to be the healthiest choice, and street lunches to be of most concern.

The present study's finding that the benefit in terms of the high vitamin A intake provided by packed lunches, with their greater fruit and vegetable content, as well as fortified spreads in sandwiches, is carried through to the total daily intake, is supported by those of the *Diets of British Schoolchildren* report (Department of Health 1989).

It must also be noted that, because the data analysed in the present study were individual days of data, rather than several days' data for an individual child, it is not possible to claim on the basis of the present study that, for example, children who eat canteen lunches have healthier diets than those eating street lunches. It is only possible to suggest that the diets consumed on days when a child has a canteen lunch are healthier than that on days when a street lunch is consumed. If a more 'child centered' analysis was required, it would be necessary to classify children as to how many of each lunch type they consumed during the study period, and therefore whether they habitually consumed a single lunch type. This was considered for the present study, but because so many children 'flitted' between lunch types over the study week, and did not have a habitual choice, the 'lunch centred' approach was judged more representative in this instance.

4.7) Ranking of lunch type quality

It has been recognised by the Scottish Government that the school lunchtime meal has the potential to improve children's diets, and therefore their health (Scottish Government 2008b), but little data is available on which is the 'best' lunch option.

To enable comparison of canteen, packed and street lunches, the present study ranked them according to lunch nutrient intake, lunch nutrient density, and also to total daily nutrient intake for days including each lunch type (to determine whether any benefit or nutritional detriment from the lunch choice carried over into the total nutrient intake).

While lunchtime nutrient intake differed greatly between canteen, packed and street lunches, this difference was lessened when the total day's intake was measured, and it was observed that all children tended to eat similar foods at times other than lunchtime. This tendency was also observed in other studies (Durnin et al. 1974; Cook et al. 1975; Department of Health 1989; McNeill et al. 2009a).

Only in the case of SFA intake, and percentage energy from SFA, did the ranking of the lunch types change between lunch and whole day intake, and in these cases, the differences between the lunch types were not statistically significant, so the swapping of ranking could have been due to chance.

For vitamin A, the difference between packed lunch intakes (the highest and most favourable) and canteen lunch intakes (the next highest), was greater (and more statistically significant) than that seen for the whole day's intake. Both this and the finding above suggest that children's diets apart from the lunchtime meal are similar, and that foods eaten outside lunchtime is generally 'less nutritious' than the canteen lunch, and 'more nutritious' than the street lunch.

The closing-up of the differences between nutrient intakes for canteen, packed and street lunches was greater for some nutrients than others. It was noted that for folate

and iron intake, there was a greater difference between canteen lunches (the most nutritious) and packed lunches (the next most nutritious) at lunchtime than over the whole day, suggesting that the (less nutritious) food eaten at other times had lessened the beneficial contribution of the canteen lunch.

Alongside this tendency for some nutrient intake differences to 'close up' when total intake is considered, the present study (in common with previous studies), found that some nutrient intake differences do remain at the end of the day. Sometimes the lunchtime option provided nutrition so poor it could not be compensated for by food consumed at other times. The most notable example was the case of fruit and vegetable intake, for which canteen, packed and street lunches showed an extremely significant difference (the greatest found in the present study) at lunchtime, which remained when the whole day's intake was considered. This was also seen in reanalysis of the FSAS sugar study (McNeill et al. 2009a).

The findings of the present study indicate that the strong nutritional advantages provided by certain lunch types – most notably canteen lunches for their relatively lower fat, SFA and NMES intakes, and packed lunches for their vitamin A and fruit and vegetable content – remain at the end of the day. When attempting to meet targets (both lunchtime and over the whole day) for fruit and vegetable intake, having a street lunch puts a child at a disadvantage.

As previously mentioned, the nutrient advantages regarding micronutrients were less evident when the total daily diet was examined. While it is encouraging that the nutritional improvements to canteen meals meant that on days children choose this option they tend to have lower fat, SFA intakes, it is less encouraging that canteen lunches' advantages in terms of micronutrient intake largely disappear by the end of the day. Although canteen lunches are significantly higher in vitamin A than street lunches, there is no significant difference in the vitamin A intake on canteen lunch days and street lunch days. (Packed lunch days, however, are significantly higher in vitamin A than either canteen or street lunch days).

Regarding folate intake, canteen lunches provide significantly more of this vitamin than either packed or street lunches. However, when total diet is concerned, canteen lunch days are not significantly higher in folate than packed lunch days. That said, the difference in folate intake on canteen lunch days and street lunch days remains highly statistically significant, and a smaller significant difference remains between packed lunch days and street lunch days.

The calcium content of canteen and packed lunches are very close, and not significantly different; street lunches are significantly lower in this mineral than both canteen and packed lunches. However, at the end of the day, there is no significant difference between the calcium intake on canteen, packed and street lunch days.

Although canteen lunches are significantly higher in iron than packed lunches, packed lunches are no higher in iron than street lunches. When the total day's diet is analysed, iron intake on canteen lunch days is not significantly higher than on packed lunch days or street lunch days.

An interesting finding is the difference between the fruit and vegetable intakes for packed (the highest), canteen (intermediate) and street lunches (the lowest) are extremely highly statistically significant at lunchtime, and remain highly significant over the whole day. This could suggest that the differences at lunchtime are so great that the food of similar nutrient content consumed at other times does not affect the significance of the whole day nutrient intakes.

Note concerning energy intake:

Energy intake could not be ranked in the same way as the other nutrients, because the SNSSL provides a target value, rather than a maximum or minimum. Street lunches showed the most favourable (closest to SNSSL) calorie intake, with the mean intake 71kcal in excess of the Standard. In terms of percentage of the Standard achieved, canteen lunches provided 78%, packed lunches 86%, and street lunches 109%. However, although street lunches had an energy intake closest to the Standard, this should not be seen as altogether positive, in the light of this lunch type's other nutritional shortcomings.

In summary:

When total daily intake is concerned, canteen lunches provide a significant nutritional advantage regarding fat, SFA and NMES intake. A significant, though smaller, advantage for canteen lunch days remains where folate is concerned. Regarding total fibre, calcium and iron intake, the lunch type chosen is not important (not significantly different) when total daily intake is considered.

4.7.1) Comparison of lunchtime nutrient density with whole day nutrient density

Although intake should be considered more important in terms of the children's health, measuring and comparing nutrient density (both for lunchtime food intake as well as total intake) provided another method of comparing the nutritional quality of canteen, packed and street lunches.

It was noted that in many cases highly significant differences ($p < 0.001$) existed between the nutrient densities of canteen, packed and street lunches, both at lunchtime and when the whole day was considered.

The superior nutrient density provided by canteen lunches (except in the case of vitamin A for packed lunches) remained when nutrient density over the whole day was considered, indicating that the benefit of this higher density carried over to the whole day's nutrient density, or alternatively that on days when they ate canteen lunches, children were eating nutrient dense foods at other times as well. Also, for every nutrient, street lunch days showed a lower nutrient density than packed or canteen lunch days, in addition to showing a lower nutrient density when lunchtime was considered.

Although the ranking for nutrient density did not differ between lunchtime nutrient density and whole day nutrient density for any nutrient, the significance of the difference between the lunch types did change in some cases. In the case of iron, the difference

between the lunchtime nutrient density of canteen lunches (highest density), packed lunches, and street lunches (lowest density) was highly statistically significant ($p < 0.001$). This difference decreased when the whole day's iron density was considered. Total daily iron density was marginally higher on canteen lunch days than on packed lunch days, but this difference failed to reach statistical significance. Packed lunch days showed a higher iron density than street lunch days, but to a lesser degree of significance ($p < 0.01$) than when this comparison was made for lunchtime iron density.

In the case of NSP, canteen lunches showed a significantly higher nutrient density than packed and street lunches (the difference between packed and street lunches did not reach statistical significance). When the whole day NSP density was considered, although canteen lunches showed a marginally higher density, this was not significantly higher than that for packed lunches. In turn, packed lunch nutrient density over the whole day was significantly higher ($p < 0.001$) than that for street lunches.

Only in the case of fruit and vegetable density was a higher degree of difference seen (between lunch types) for whole day density when compared with lunchtime density. While packed and canteen lunch densities of fruit and vegetables were not significantly different, canteen lunch days showed a significantly higher fruit and vegetable density ($p < 0.05$) than packed lunch days. (Both in the cases of lunchtime and whole day density, street lunches and street lunch days showed significantly lower fruit and vegetable density than the other two lunch types ($p < 0.001$)).

For vitamin A, folate and calcium, the ranking, and degree of significance of difference, remained unchanged when lunchtime density, as well as whole day density, were considered.

4.7.2) The superiority of canteen lunches in terms of nutrient intake and density

In terms of nutrient intake, canteen lunches were found to be significantly nutritionally superior (both at lunchtime and over the whole day), regarding fat, SFA, NMES, folate, calcium and iron. Packed lunches were found to be significantly superior (both at

lunchtime and over the whole day), in terms of intake of vitamin A, and fruit and vegetables. However, when nutrient density was considered, canteen lunches were found to be superior in the case of every nutrient, as well as fruit and vegetables.

Also, the degrees of significance of the differences between canteen, packed and street lunches were greater (with almost all reaching $p < 0.001$) when nutrient density was considered, than was the case when comparing the nutrient intake for the lunch types.

For example, while canteen lunches did not show a significant benefit over the other lunch types regarding intake for NSP and iron, examining and comparing nutrient densities indicated that canteen lunches are significantly richer in these nutrients than packed and street lunches (except in the case of total daily nutrient intake for iron, where although canteen lunches are significantly superior to street lunches, they were not significantly different to packed lunches).

The issue remains: are some nutrients more 'important' for overall nutrition and health than others? If a lunch option provides more of certain nutrients, does this hold more importance when ranking lunch options for quality of nutrition?

It was acknowledged in the version of the school lunchtime standards in place when the present study was conducted that some nutrients should be emphasized when setting standards for lunchtime target intakes (Scottish Executive 2003b). While lunch might be expected to provide one-third, or 33 percent, of a child's intake of a given nutrient, the standard was set at 35 percent for calcium, and 40 percent for iron and folate, due to the paucity of these nutrients in children's diets (Gregory & Lowe 2000).

It might also be argued that the macronutrients – calories, fat, SFA and NMES – should be given greater prominence, due to their negative impact on childhood and adult health if consumed in excess. However, because no validated ranking of importance of nutrients exists, for the purposes of this discussion, each nutrient was given equal weighting.

It was concluded that canteen lunches provided the 'most nutritious lunch', followed by packed lunches, with street lunches providing the 'least nutritious lunch'.

(If percentage energy from fat, SFA and NMES had also been included, the ranking would have remained unchanged).

4.7.3) Studies examining all three lunch types for both lunchtime and whole day intake

It was possible to locate two other studies which considered the three lunch groups analysed in the present study, both at lunchtime and over the whole day. It must be noted that these studies categorized children to a habitual lunch type, in contrast with the present study which analysed days including each particular lunch type. So, in effect, the other studies sacrificed some accuracy by classifying children to a particular lunch type most days (but not necessarily, every day), in order to concentrate on how a child's usual behaviour affects their nutrition. The present study retained accuracy by categorizing data into 'days' rather than 'children', but lost the ability to obtain conclusions regarding children's habitual behaviour. This was a conscious decision by the author at the outset of the study, as it was decided that it would still be relevant to make comparisons with other studies, in particular regarding their rankings of which lunch type was nutritionally superior.

Study 1, the *Diets of British Schoolchildren* report (Department of Health 1989) was conducted in the UK before the 2001 introduction of food-based nutrient standards for school meals in England.

Study 2 (McNeill et al. 2009a) was conducted in Scotland, after the 2003 introduction of food and nutrient-based standards for school meals in Scotland.

Study 1 (Department of Health 1989) found that, for intakes of all nutrients, rankings (of lunch types) from highest to lowest remained the same whether lunch intake, or total daily intake, was considered. Children eating school lunches were found to have the

highest energy and fat intakes both at lunchtime and over the whole day, with those consuming street lunches having the lowest intakes (packed lunches showed intermediate results). This situation is the reverse of that observed in the present study. However, the ranking of intake of vitamin A was the same as that for the present study, with both packed lunches and packed lunch days providing the greatest amount, and street lunches and street lunch days the least.

Regarding calcium and iron, packed lunches provided the highest intake (at lunchtime and over the whole day), and street lunches the lowest. This contrasted with the present study, where although street lunches (and days including them) still provided the lowest calcium and iron intake, the highest was from canteen lunches (and days including them).

Two notable differences between Study 1 and the present study are the date of data collection, and whether nutritional standards were in place. It appears that although at the time of the earlier study, canteen lunches made the least favourable health and nutrition contribution to children's diets regarding energy and fat intake. Study 1 also noted the poor nutritional quality of canteen lunches dominated by 'chips, buns and pastries' in the years before the introduction of nutrient standards in 2001.

This situation was reversed when data was collected for the present study after the introduction in the Scottish nutrient standards, with canteen lunches making the most favourable nutritional contribution. Regarding calcium and iron intake, while the earlier study found packed lunches to provide the most favourable input to children's diets, the present study found canteen lunches to do so, indicating that the new nutrient standards are making a positive contribution to Scottish children's nutrient intakes, in comparison to times when nutrient standards were not in place. However, canteen lunchtime intakes of these nutrients remain too low.

When vitamin A intakes were examined, both the earlier and the present study found packed lunches to provide the most beneficial dietary input, and street lunches the least. Then as now, packed lunches contained more fruit and vegetables than the other lunch options, boosting children's intake.

In common with the present study, Study 2 (McNeill et al. 2009a) found intakes of energy and NMES both at lunchtime and over the whole day to be highest for children consuming street lunches, and lowest for those consuming canteen lunches. The intake of SFA (both at lunchtime and over the whole day) was highest for children consuming packed lunches, the same finding noted by the present study.

Nelson et al (2007b) conducted a secondary analysis of the NDNS for young people (Gregory & Lowe 2000). The study examined the contribution of canteen lunches to nutrient intake, noting that canteen food tended to include more foods considered to be less healthy (high-fat main courses, desserts, chips and other fried vegetables) than food consumed at other times of day. The canteen food was also lower in more nutritious foods (pasta, rice, bread and other cereals, milk and milk products). However, in other respects, the canteen meals were healthier than food consumed at other times, as they contained less sugar, preserves and confectionary, and more vegetables. The authors concluded that canteen meals could be 'making matters worse, rather than better.' It must be noted, however, that the NDNS data dates from before the 2001 introduction of food-based nutrient standards for England, at a time when canteen lunches were certainly less nutritious than those provided under the food- and nutrient-based standards in place in Scotland (Scottish Executive 2003b) at the time of the present study.

In summary: At the time of the *Diets of British Schoolchildren* report (Department of Health 1989), which was conducted before the introduction of nutrient standards for school meals, canteen lunches were a poor nutritional choice, especially regarding their high fat and low micronutrient content. At this time, packed lunches appeared to be the healthiest option. However, early canteen lunches could be higher in micronutrients than modern (post-introduction of standards) canteen lunches, possibly due to the larger quantities of food consumed.

In the modern studies, particularly the Scottish studies conducted after the introduction of nutrient standards, canteen lunches provided the most beneficial profile, with the exception of vitamin A and fruit and vegetable intake (and in the cases of the FSAS

study (McNeill et al. 2009a), also calcium), for which packed lunches provided a greater input. Canteen lunches now also provide less fat, and greater amounts of micronutrients, though the levels of micronutrients provided still fall below the nutrient standards for school meals.

For all of the studies compared (regardless of the year of completion), street lunches were nutritionally poor, and generally the poorest option.

Chapter 5 – Conclusion

5.1) Canteen lunches

5.1.1) Discussion of the nutritional quality of canteen lunches

The present study demonstrates that canteen lunches provide a superior nutritional profile to packed, and especially to street, lunches. This holds true in terms of nutrient intake, and especially in terms of nutrient density. (Although packed lunch days provide marginally greater intakes of some micronutrients, they are only significantly greater than those for canteen lunch days in the case of vitamin A). In addition, and of greater relevance in terms of health, the advantages in terms of nutrient intake provided by consuming a canteen lunch are still apparent when the whole day's nutrient intake, and nutrient density, is considered. Days including canteen lunches have lower intakes of fat, SFA and NMES than days including packed or street lunches. They also provide more folate and calcium.

Despite this encouraging finding, the nutritional intake of children choosing canteen lunches is still of concern. The SNSSL standards in place at the time of the present study (Scottish Executive 2003b) stated that canteen lunches should provide a certain proportion of the DRV for nutrients (a maximum for fat, SFA and NMES, and a minimum for NSP, vitamin A, folate, calcium and iron). In the present study, canteen lunches provided too high a proportion of the DRV for SFA and NMES, and an insufficient proportion of the DRV for NSP, vitamin A, folate, calcium, iron, and fruit and vegetables. However, since canteen lunches provide nutritional advantages over packed and street lunches, it is still worth encouraging their uptake.

5.1.2) Improving the nutrition provided by canteen lunches

Compared with other developed countries, including the USA, Canada, Australia, Norway, Sweden, France, Spain and Germany, the nations of the UK have the most stringent nutritional regulations for school meals, in terms of both food- and nutrient-based standards (School Food Trust 2007a).

Even if the overall menu, considered over a week (as stated in the SNSSL), may meet the standards for school meals, the present study indicated that the actual lunchtime nutrient intakes of children consuming canteen lunches were often far from the standards. This was due to the food choices made by the children.

In order to meet the standards, the children's canteen lunch choices need to contain more calcium, iron, NSP, and most notably, fruit and vegetables. If their intakes of foods rich in these nutrients and foods were increased, it is possible that the consumption of the nutrients considered detrimental in excess (fat, SFA, NMES) could consequently fall. If children fill up with high nutrient density foods such as semi-skimmed milk, wholemeal sandwiches with fillings such as lean meat, and fruit and vegetables, it is possible that they might have less appetite for the less nutritious items on the menu.

Encouraging healthy choices

Once children have decided to eat in the school canteen, various means of steering them towards healthy choices have been attempted, including not allowing children to purchase only chips, or repeat items (for example, two slices of pizza) (Bowker et al. 1998).

However, guiding children's choices is by no means easy. One of the stumbling blocks faced by interventions where unfamiliar healthy foods are introduced, as was reported in the case of the high profile school meals campaign launched by TV chef Jamie

Oliver, is that children are expected to try, and accept, healthy foods they have never encountered before (London Evening Standard 2007a). It has already been noted that children can be very set in their ways when it comes to choosing old favourites rather than trying new foods (Brannen & Storey 1998; Passmore & Harris 2005), and research on younger children has found that simply showing children a new food does not increase their preference for it; children must actually taste the food, and often repeatedly, before they will accept it (Birch et al. 1987).

In addition to this so-called neophobia, children's reluctance to waste money on trying foods they might not like (Scottish Executive Expert Panel on School Meals 2002, Sinclair & Winkler 2008) makes it difficult for schools to introduce pupils to new, healthier items on the canteen menu. The new SNSSL standards introduced in 2009 (Scottish Government 2008b) recommend that small taster portions are used to introduce children to unfamiliar dishes, such as fish dishes. In the light of children's financial awareness, they are unlikely to be willing to pay for tasters of foods that they may not like, so the author of the present study would anticipate that it would be necessary for these to be free samples in order to persuade pupils to try them. However, children's price awareness could be positively harnessed by promoting cheaper 'meal deals' on healthy foods, and subsidising the healthiest choices (Lowden & Schlapp 2002).

Pupil involvement has been found to encourage participation in initiatives to improve nutrition in schools (Lowden & Schlapp 2002; Passmore & Harris 2005). The smaller school (St Columba's) in the present study ran a trial of a 'smoothie bar' operated by older pupils (though not during the data collection period for the present study), which proved popular in engaging pupils, and the author of the present study suggests that it is possible that such stalls, selling healthy items, might encourage children to stay in school to purchase their food, whether from these stalls or also from the items on the school canteen menu.

Provision of fruit and vegetables

It was noted from the present study that fruit and vegetables were the most extreme lack found in the children's diets, both over the whole day, and also in every lunch type, including canteen lunches, which had a mean fruit and vegetable intake of 0.28 portions (compared with 0.48 portions for packed lunches and 0.09 portions for street lunches). The SNSSL standard in place at the time of the present study (Scottish Executive 2003b) required 2 portions of fruit and vegetables in a school lunch, and the Government target (Department of Health 2003a) is for 5 portions of fruit and vegetables a day.

The new SNSSL standards (Scottish Government 2008b) introduced after the present study note that low consumption of fruit and vegetables remains one of the most concerning features of the Scottish diet. In common with the previous standards, they state that a school lunch should contain a minimum of two portions of fruit and vegetables, and that a choice of at least two types of vegetables and two types of fruit (not including fruit juice) must be provided every day as part of the school lunch.

One of the suggestions proposed in the SNSSL for increasing fruit and vegetable intake as part of school lunches is the addition of vegetables and pulses to hot dishes such as stews, and fruit to hot desserts such as apple crumble. However, it was noted during the present study that hot dishes were unpopular with the children, and prove wasteful and uneconomical for school catering departments to provide. Because of this, catering departments were unwilling to cook them, and only a limited range was available.

Another suggestion from the SNSSL, which the author of the present study feels could prove more successful in improving children's lunchtime vegetable intake, is to investigate the provision of soups. Soup was (along with chips and pizza) the most popular item chosen as part of canteen lunches by children in the present study, and was also commonly consumed regularly at other times. This fondness for soup appears to be a characteristic of the Scottish diet (Gregory & Lowe 2000), and since the Scottish

diet is generally low in vegetables in other respects, (Gregory & Lowe 2000; Henderson, Gregory, & Swan 2002) the author of the present study suggests that it would seem sensible to work with this potentially beneficial dietary trait to maximise children's lunchtime vegetable intake.

Soups are generally inexpensive and easy to prepare, and these financial savings could be passed on to the children, making the price of soups competitive with foods available outside school. The author of the present study suggests that soups' recipes could be devised to maximise their vegetable (and nutrient) content, including a wide range of vegetables. Vegetables that children might not otherwise choose could be incorporated by 'hiding' them in the soup. The protein content could be maximised by including pulses. A 'soup counter' could serve takeaway cups of soup, appealing to children's desire to purchase food that is quick and easy to consume while standing or walking. A wholemeal bread roll and a piece of fruit could be sold at the same time, creating a 'meal deal'. Although it would be preferable for the soup to be eaten in school, the author suggests that it would still provide benefits if it was taken away from the school premises (due to children's desire to leave school during their lunch break). Soup has been found to be particularly sustaining (Mattes 2005) and the fact that children had consumed a portion of soup might dull their appetite for high-fat high-sugar street food. Soup bars could also be operated during the school morning break, when many children in the present study consumed significant amounts of food less conducive to health.

While they were not one of the most popular choices, salad boxes were eaten by several children in the present study. Possibly their appeal could be increased by providing a 'pick and mix' salad bar (if this could be provided cost-effectively), or asking children (through a consultation group) which vegetables they would prefer to be included in any set salad boxes. Increasing the variety of salads by including rice salads, pasta salads and noodle salads, all with high vegetable contents, might also increase uptake and boost children's vegetable intake.

The author suggests that the salad content of sandwiches, baguettes and wraps could also be increased, possibly so that all bread-based lunches contained salad. In the

present study, some sandwiches, baguettes and wraps contained salad, while others did not. The inclusion of salad appeared not to influence children's choices; they were no more likely to choose salad-free items, so removing these from the menu is unlikely to prove a problem. (More problematic would be persuading children to eat wholemeal bread, as white bread sandwiches were selected almost exclusively).

Increasing availability of fresh fruit has been found to encourage its consumption (Kratt et al 2000). A choice of fresh fruit (as pieces of fruit or in fruit salad boxes) must be offered as part of school lunches in Scotland, and encouragingly, in at least one of the schools in the present study (information from a telephone call to the Catering Department of St Columba's High School on 3 September 2009) canteen purchases of fresh fruit, and also fresh fruit salad boxes, increased after the arrival of the Autumn 2009 intake of first year pupils who were accustomed to the new and more stringent nutrient standards (Scottish Government 2008b) previously introduced in primary schools across Scotland.

Pieces of fruit are quick and easy to eat, and sweet tasting, and children are known to have an innate liking for sweet tastes (Drewnowski 1989). It is also easier to increase children's intake of fruit than vegetables (French & Wechsler 2003). Fruit could therefore appeal to children's taste preferences and liking for 'convenient food' to eat quickly and on the move. Increasing the opportunities for pupils to pick up fresh fruit at school would seem to the author of the present study an ideal way of helping them to meet the SNSSL standards, as well as the 'five-a-day' Government target. Fruit could be available from several points in the canteen, without the need to join queues for other food.

Children's diets are characteristically high in snacks (Anderson et al. 1993; Gardner Merchant 1998), and fruit is a convenient snacking food, so fruit could be encouraged as a snack food that would be permitted to be served in schools under the new SNSSL standards. Many schools also provide 'fruit bars' serving fresh fruit, both at lunchtime and morning break (Bowker et al. 1998). These can be situated in locations outside the canteen, to attract children having packed or street lunches. They can also be run by older pupils, and pupils can be consulted on which fruits they would like to eat. Fruit

provision (especially the variety of fruit served) can also be targeted in school tuck shops.

One of the schools in the present study ran a trial of a 'smoothie bar' serving freshly made fruit smoothies, run by older pupils during morning break. Although the limited availability of smoothie-making equipment meant that only a limited number of children could be served during each break time, the pilot scheme proved very popular, indicating the potential of pupil-based initiatives such as this.

Healthy vans

Both schools in the present study had a 'Healthy Van' parked in the school playground during morning break and lunchtime, enabling children to purchase food prepared by the canteen staff, such as pizza, baguettes and sandwiches prepared from the same healthy recipes used by the canteen, from an alternative location to the canteen. These vans proved very popular; canteen staff informed the researcher that children said that they preferred them to using the canteen. The children said that the queues seemed shorter, and they preferred not having to use the dining hall environment. They also preferred paying using cash, rather than the 'smart cards' used in the canteen.

It is possible that the pupils perceived purchasing from the Healthy Van as being similar to going outside school to buy a street lunch, and also a means of eating somewhere other than the unpopular dining hall environment. Since the food being served from the Healthy Van was the same as that in the canteen and abided by the SNSSL standards, these vans should be encouraged as a way of encouraging children to stay on school premises and consuming a nutritious lunch.

5.1.3) Problems encountered when improving the nutrient content of school lunches

"It won't be the regulations alone that encourage young people to eat healthy, nutritious school meals," said Adam Ingram, Minister for Children and Early Years, in the

introduction to the revised *Scottish Nutrient Standards for School Meals* (Scottish Government 2008b). He continued, “We need to be sure that our children and young people enjoy the food and drink provided.”

Even the most nutritious food will have no benefit to children’s health if it isn’t eaten. Although the introduction of the SNSSL has improved the nutritional quality of canteen lunches, and the children who do consume them are reaping the nutritional benefits (even when the whole day’s nutrient intake is considered), uptake of canteen lunches have been reported to have fallen (see Table 5, Scottish Government 2005). This means that fewer children benefit.

Children today have more freedom than their predecessors in many areas of life, including their food choices. School canteens have gone from providing rather rigid school dinner menus with limited choice to a cafeteria system with great choice (Brannen & Storey 1998, Passmore 2004). In addition, it was noted during the compilation of the literature review for the present study that in earlier studies it was much rarer for children to have the option to eat a lunch purchased outside school (a street lunch) than is the case at present. By the time of the pilot study (Norris 2005) for the present study, at least in the town studied, a street lunch was as likely an option as a canteen or packed lunch, and the last and most recent comparable Scottish study (McNeill et al 2009a) found street lunches to be a common source of lunchtime food. The increasing popularity of street lunches was also noted in the Sodexo School Meals and Lifestyle Survey (2005).

If the canteen lunch is less appealing than the other options available, the pupils will vote with their feet, go elsewhere and make alternative food choices. Now that leaving school at lunchtime to buy their own food is a far more acceptable, and frequent, option for today’s children than for previous generations, school canteen menus are forced to compete with fast food outlets nearby, as well as snack vans parked in the streets, plus the option of bringing a packed lunch. All of these could include foods not permitted on the canteen menu.

It is not only the nature of the food available outside school that draws children away from the canteen. 'Getting away from school', and 'being with friends' were quoted as the most important reasons for having a street lunch, in an earlier study by the researcher (Norris 2005).

The statistics for falling uptake of canteen meals since the introduction of the school lunch standards in Scotland speak for themselves. School lunch uptake was already falling in 2006 when the first SNSSL standards (Scottish Executive 2003b) were introduced, and continued to decline, with uptake declining from 43.4% to 39.2% between 2006 and 2009. The rate of decline also accelerated, with a fall of 1.5% between 2005 and 2006, and of 3.7% between 2008 and 2009, when the new, stricter nutrition standards (Scottish Government 2008b) came into force in secondary schools Scotland-wide. These newest standards presented children with a far greater restriction of the foods available to them in the canteen than the previous standards, most notably by stopping the sale of chocolate and other confectionary (and foods containing them), sweetened and fizzy beverages, and all but a limited range of savoury snacks (which were only permitted for sale outside lunch times). In 2010, the downturn in school meal uptake in Scotland was reversed, showing a slight (+0.4%) increase to 39.6% (Scottish Government 2010d).

The introduction of the more stringent standards (Scottish Government 2008b) ahead of schedule in the county of Fife (where the present study was conducted), brought the county's uptake figures from being one of the highest in the country to showing a far more dramatic decrease than those seen previously in Fife, or in other counties at the same time. Between 2007 and 2008, uptake in Fife fell by 1.4%. In 2009 (after the introduction of the new, stricter standards), it fell by 14.1%, but (similar to Scotland overall), the next year (2010) saw a slight increase (of 0.7%) with uptake figures of 44.4% (Scottish Government 2010d).

The newest SNSSL standards (Scottish Government 2008b) were fully introduced at the schools in the present study at the beginning of the academic year following data collection. St Columba's High School, the smaller school in the present study, informed the author that canteen takings fell by £300 per day in the months after the new nutrient

standards were introduced in 2008 (and after the present study was conducted) (information obtained from a telephone call to the Catering Department of St Columba's High School on 3 September 2009). Catering staff at Queen Anne High School, the larger school in the present study, commented in a telephone conversation conducted on 4 June 2009 that the number of children using the canteen halved within a few months of the new standards' introduction.

However, in 2010 Scotland-wide uptake showed a slight increase of 0.4%, to 39.6%, and in Fife, uptake increased by 0.7%, to 44.7% (Scottish Government 2010d), see also Table 5.

It has already been noted, from the present study and others, that a street lunch is the least nutritious lunchtime option, and the nutrition it provides is so poor that this cannot be compensated for over the rest of the day. It is possible that the new, stricter Scottish nutrient standards initially drove children away from canteen meals, straight to the fast food vendors outside the school, and to high street bakers and supermarkets, where a wider variety of food, much of it high in fat, SFA, sugar and salt, was available.

It is possible that the recent, more stringent, changes to school meals were 'too much, too soon', and that children did not have time to become accustomed to the new, healthier menus. This suggestion has been widely discussed in the media and mooted in the popular press in England (London Evening Standard 2007b) and Scotland (Brown, C. 2009). If the media reports provide a true representation of children's views, it is possible that they felt deprived of the favourite foods they were accustomed to being able to purchase in school, and therefore decided to purchase them elsewhere.

Research suggests that it has been usual for children's diets to deteriorate in nutritional quality with the progression from primary to secondary school (Gregory & Lowe 2000). The new nutrient standards (Scottish Government 2008b) came into force in Scottish secondary schools in the Autumn term of 2009, but they had been introduced in primary schools the previous year. The Scottish Government (Scottish Government Education Department 2009b) hopes that when children who had passed through the primary school system in the years following the introduction of the new standards in 2008,

arrive at secondary school, they might be accustomed to eating the healthier foods on the menu there, and therefore continue to eat canteen meals, reversing the decline in uptake. This has been found to be the case in one of the schools in the present study (information obtained from telephone conversations with catering staff at Queen Anne and St Columba's High Schools on 4 June and 3 September 2009), where the uptake of canteen meals increased noticeably when the Autumn 2009 intake of first year children arrived at the school. The decline in canteen meal uptake seen after the introduction of the new standards at the secondary school was not entirely reversed, but there was a noticeable upturn. However, it must be noted that this correspondence dates from just three weeks after the new intake arrived at the school; it remains to be seen whether this encouraging increase in consumption of healthy canteen lunches can be maintained. It seems unlikely that there would not be some decline in uptake when children encounter the greater freedom to purchase their own lunches outside school, combined with the characteristic eating patterns, including bowing to peer pressure, reluctance to eat food seen as 'healthy', and wanting to assert independence (Ludwigsen & Sharma 2004, Sodexo 2005), that characterise this age group.

In England, introduction of legislation to improve school meals in 2006 (School Food Trust 2007b) led to an immediate downturn in uptake of school meals, followed by a slower recovery. When the interim standards were introduced in 2006, uptake had already been falling, but this decrease accelerated, with uptake decreasing (School Food Trust 2009) from 42.3% to 41.3% in primary schools, and 42.7 to 37.7% in secondary schools for the year 2005/6 – 2006/7. The following year saw a slight increase to 43% in primary schools, but a very small decrease to 37.6% in secondary schools (School Food Trust 2009).

A change in methodology was then introduced, meaning that previous trends could not be compared with the new data. However, the data for 2007/8 compared with 2008/9 shows a small continuation in increase from 43.8% to 43.9% and from 35.5% to 36.0% in secondary schools (School Food Trust 2009).

5.1.4) Increasing uptake of canteen lunches

Over the years, various methods have been employed to increase uptake of school meals. Due to children's characteristic eating patterns and preferences for less healthy foods, if they are to be successful these endeavours must always recognise that achieving this aim will be a compromise between what children are prepared to buy and eat, and what is nutritious.

Keeping children in school

In order to persuade children to have canteen rather than packed or street lunches, it is necessary for children to be aware of what is available in the canteen; pupils who have not visited the dining hall for some time may be unaware of any initiatives introduced to increase uptake of school meals by making them more appealing. Therefore, children must be persuaded into the canteen in the first place – only once they have seen what is available can they be encouraged to stay. Alternatively, menus could be displayed outside the dining area – though this would obviously not allow the pupils to view the actual food.

Means of persuading children to stay in school rather than leaving the premises would also prevent them from consuming unhealthy street lunches, which tend to be high in fat, SFA, NMES and salt, and low in beneficial nutrients. The author of the present study believes that school clubs could encourage children to stay on school premises, particularly if a lunch that was appealing yet easy to arrange and consume (for example a filled baguette, a drink and a piece of fruit) was arranged for participants.

Several schools have attempted 'lock in policies' whereby children are not permitted to leave school premises during lunchtime without special permission, and there have been calls for more schools to initiate these policies. For example, in July 2008, Kevin Brennan, the then Westminster Government's Children's Minister, expressed his

support in a national newspaper article for 11 – 16-year-old pupils to be kept on school premises during school hours, after the revelation that some children left school to buy unhealthy food high in sugar and fat more than 11 times per week (Campbell & Asthana 2009).

A pilot scheme was launched in eight Glasgow schools in August 2009, whereby first year secondary school pupils would be offered the choice of a canteen lunch, a packed lunch from home, or returning home for lunch, with no option to buy their own street lunches (Brown 2009b). The scheme was scheduled to run until 2010 and, if successful, be rolled out to include other schools and year groups. At the time of writing, no information was available on the success of the initiative.

Not only do lock-in policies improve children's nutrition by preventing them from purchasing street lunches, they also have safety advantages, by keeping children away from busy roads, a factor which might help in convincing those opposed to the scheme to accept them. Although resistance to lock-ins by pupils and parents has been reported (Brown 2009a), schools that succeed in fostering acceptance of lock-in policies are likely to have a higher proportion of children consuming nutritionally acceptable lunchtime meals, and by extension, more likely to have acceptable overall nutrient intakes. It is the author's opinion that a lock in policy would be an extremely effective means of improving children's lunchtime nutrition, but the resistance in terms of acceptance by children and parents is unlikely to be overcome without an enormous shift in public perception of the personal freedoms to which children should be entitled.

Also, keeping children on the premises would not force them to eat the healthy canteen lunches. Even if children are not allowed out of school to purchase their own food, they may still bring their own packed lunches from home, in order to obtain foods no longer permitted on the school menus, such as crisps, confectionary and sugar-sweetened drinks. These are already frequently included in packed lunches, and if a proportion of children previously eating street lunches change to packed lunches, the amount of this kind of high-fat, high-sugar foods in lunchboxes could increase. When the uptake of canteen lunches in the schools which took part in the present study fell following the early introduction of the new SNSSL standards (Scottish Government 2008b), some of

these children started bringing packed lunches instead (information obtained from a telephone call to the Catering Department of St Columba's High School on 3 September 2009).

Children kept on school premises during lunch time would also still be able to buy their own food on the way to school, for consumption at lunchtime. This would effectively be a street lunch purchased in advance. Although this would not include hot food options such as chips or burgers, it would not prevent children from buying foods such as crisps, sausage rolls, doughnuts, chocolate, sweets and sugar-sweetened soft drinks, to be consumed as their lunchtime meal. Therefore, unless a school instituted some kind of control of the foods children bring in to school for lunchtime consumption, any lock-in policy's effectiveness in improving lunchtime nutrient intake would most likely be compromised. And, as already noted in this discussion, attempts to 'control' children's food choices almost always face strong opposition from parents and children. Also, it could be expected that any attempt to examine and approve or otherwise the foods brought in to school by children would face strong opposition from both pupils and parents.

The role of School Nutrition Action Groups

As part of the Health Promoting Schools programme, many schools (although neither of the schools in the present study) have set up School Nutrition Action Groups (SNAGS) (Learning and Teaching Scotland 2008; Health Education Trust 2009). These are consultation groups involving pupils, staff (teaching and catering), parent representatives and external agencies such as dieticians or health promotion workers. SNAGS allow pupils to make their views known so that, where feasible, their views can be incorporated into food provision in their school. It would be hoped that pupil consultation would both increase the 'child appeal' of the food the food provided and the canteen environment in which it was served. It could also foster a spirit of involvement among pupils whereby children would be more likely to use the canteen, or other healthy eating initiatives introduced by the SNAGS.

However, children's propensity to make poor dietary choices are well known, and the authors of a study on the contribution of school meals to children's overall nutrition (Nelson et al. 2007b) asserted that "Widening children's choice of foods at lunchtime has had a detrimental effect on overall diet". Teenagers' tendency to favour unhealthy food choices, and to associate 'fast food' options such as burgers, pizza, chips and fizzy drinks with children who are popular and successful, was noted in a survey commissioned on children's attitudes towards 'healthy' foods, and also the kinds of foods that appealed to children (Ludwigsen & Sharma 2004). Other surveys have found pupils' canteen lunch favourites to be burgers, pizza, chicken nuggets and pasta (Consumer Association 2003; Sodexo 2005).

It might therefore seem unwise to ask children which foods they would like on their canteen menu, as it is likely that children involved in SNAGS panels would request these foods, and possibly feel disappointed, and that their views were not important, if they were not introduced onto the menu.

To determine the impact of SNAGS on children's food choices, an intervention involving secondary schools with and without SNAGS was carried out (Passmore & Harris 2005). The pupils' most frequent request was for improved choice on the canteen menus (28% of pupils), and it has also been noted that children starting secondary school and encountering a cafeteria school meal system for the first time found the freedom and choice appealing (Brannen & Storey 1998). However, in practice children have been found to be very conservative in their lunchtime choices, tending to favour the same few dishes and food items every day (Brannen & Storey 1998). It is also common for children to have decided what they are going to eat for lunch before they enter the canteen (Passmore & Harris 2005).

It is therefore likely that, rather than having any intention of eating more than a small proportion of the foods they suggested, the children in the SNAGS study simply wanted

to feel that choices were available to them, and that their views were being respected. In addition, teenagers' preferences for familiar favourites, and their reluctance to try new foods (especially with the added impact of peer pressure (Ludwigsen & Sharma 2004)) mean that new dishes are likely to remain untried.

Price

The second most important factor mentioned by children in the study on the effectiveness of SNAGS (Passmore & Harris 2005), as well as in the literature review on the uptake of school meals compiled prior to the introduction of Scotland's Hungry For Success programme (Lowden & Schlapp 2002), and an Ofsted report on encouraging healthier eating in schools (Ofsted 2007a), was price.

The price of lunchtime foods was not recorded as part of the present study. Schools are limited in the budget available to spend on school meals, but the fact that children are so price-conscious makes it particularly important that the foods served in school are competitive when compared with prices at outlets outside the school, many of which offer 'meal deals' of high-fat, and often high-sugar foods, such as sausage rolls, bridies (meat pasties), doughnuts and fizzy drinks, which are appealing to children. Children also save money by buying in bulk and sharing food, a behaviour noted in the pilot study conducted by the author (Norris 2005), and in a study on street food consumed by secondary school pupils in London (Sinclair & Winkler 2008).

In the SNAGS study (Passmore & Harris 2005), 16% of pupils also requested more healthy food on the canteen menu. In light of their habitual food choices, and the results of this study (with the new foods not being eaten), it is likely that these pupils were asking for the foods they thought they ought to request, rather than those they intended to eat. A review of food and nutrition activities in Health Promoting Schools (Bowker et al. 1998) also noted that pupils on SNAGS consultancy committees tended to request foods that they had been taught were healthy, and that they anticipated would be accepted by the adults on the committee, rather than the foods they actually wanted and intended to eat. Even when the SNAGS in the study introduced changes to canteen

menus, these were not noticed by 51% of pupils, with the increase in variety being the change most noticed (Passmore & Harris 2005).

Despite the limitations noted, the author of the present study believes that SNAGS are worthwhile interventions, although children need to be alerted to the fact that all involved will be disappointed with the results if the views put forward by pupil representatives are not their true opinions. Pupils must also be briefed on the budgetary limits and nutritional standards that schools are constrained by.

Loyalty cards and reward systems

Loyalty card systems can also encourage children to purchase from the canteen, whereby they collect stamps on a card which can be redeemed when they have collected sufficient for free lunch items, or non food gifts deemed suitable by the school. Loyalty/reward systems can be incorporated with a smart card used to pay for school meals, this streamlines the process further, as well as enabling the effectiveness of this kind of promotion to be monitored (CRB Solutions 2010a).

Various interventions have been attempted whereby children collect 'points' by purchasing healthy foods in the canteen, which can be exchanged for prizes such as mobile phone vouchers and music downloads. An example of this is the 'Pukka Stuff' scheme operated by North Lincolnshire City Council (North Lincolnshire City Council 2008; Hull Daily Mail 2008), and similar initiatives have also been introduced in Scotland (Scottish Government Education Department 2009b). In 2004 Midlothian Council, Scotland, introduced a reward-based 'points' system in four High Schools, utilising the IMPACT cardless payment system (Catto 2010). Each dish on the menu was allocated a points value by a nutritionist, according to its 'healthiness', and the four students who had collected the most points at the end of the term won an i-pod music player. The scheme proved a success, and in 2010 was in place in all six High Schools in Midlothian. After consultation with pupil councils, i-pod players have been replaced with music download vouchers, awarded to the top-scoring 30 pupils in each school. Data collected from the children's payment cards for monitoring under the *Hungry for*

Success programme indicates an upward trend in the points scores on the children's payment cards, indicating that their lunchtime food choices are becoming more conducive to good health (Catto, 2010).

Although some might consider reward schemes 'bribery' to persuade children to eat healthily, it is the author's view that this is an ethically acceptable means of tempting children to remain in school during lunch times, and keeping them away from the potentially less nutritious street food available outside school premises. Points schemes could also be an effective means of encouraging children to try novel foods, if these are allocated extra 'points'. Introducing children to new foods could have a knock-on effect, improving their overall diets, if they go on to ask for these foods at home.

Increasing awareness of the nutritional benefits of school lunches

Another incentive to encourage parents to persuade their children to eat school lunches would be to promote their nutritional advantages, perhaps supported by data such as that obtained by the present study. Although children would be less likely to be swayed by this argument, thanks to their attaching greater importance to taste than nutrition (Ludwigsen & Sharma 2004), parents might encourage their children to take school lunches if they were aware of their benefits. If canteen meals were made more competitive in comparison with street lunches, especially now that parents of children in many schools are able to pre-load smart cards with lunch money (thus avoiding their concern regarding children spending the money elsewhere), the author of this study believes that parents might be more likely to take heed of this line of reasoning.

5.1.5) Addressing factors discouraging children from consuming school lunches

Factors quoted by children as discouraging them from taking canteen meals include the following (Storey & Chamberlin 2001; Lowden & Schlapp 2002; Ofsted 2007b; Ofsted 2010c):

- Unappealing food
- Lack of choice
- Price/value for money
- Unattractive dining halls
- Overcrowding in dining halls
- Being unable to sit with friends having packed lunches or going out to buy street lunches
- Lack of time to purchase and eat lunch
- Long queues
- Competing activities such as school clubs

It is the opinion of a research group from the Nutrition Policy Unit at London Metropolitan University that children do not venture out onto the streets to buy their own food because they dislike the healthy menus, but because of the unappealing canteen environment (Sinclair & Winkler 2008). It was also the experience of the author of the present study during the pilot study for the present research (Norris 2005) that the food was a relatively minor disincentive to choosing to have a canteen meal. Some schools, including the school in the pilot study, have introduced technological features such as music, and screens showing music videos, in canteens, but informal discussions by the author with participants in this study revealed that these are seen merely as 'window dressing', and that the disincentives of noise, overcrowding, and feeling rushed and stressed, are seen as far more important.

Fife Council has recently refurbished several of its school dining rooms. After the present study was conducted, the canteen at St Columba's High School (the smaller

school in the study) was refurbished with new tables and chairs, and a window-side 'breakfast bar' for additional seating. Staff at the school told the author of the present study that the children said they "liked" the improvements, but that it had not halted the declining uptake of canteen meals following the introduction of the new standards. Queen Anne High School is a relatively newly built school, and was not refurbished.

Lack of time and queuing

Children prefer food that allows them to buy and finish their meal quickly because they want to participate in non-food activities at lunchtime (Wills et al. 2005), preferably without the need to sit down, and perhaps while they are walking from place to place. The rushed and stressful atmosphere of the dining room, compounded by children's feeling that they are 'wasting time' in long queues, is frequently cited as a disincentive for pupils to use school canteens (Lowden & Schlapp 2002; Wills et al. 2004; Ofsted 2010b). School meals are often rushed affairs, with large numbers of children needing to be fed within a limited amount of time. Ironically, schools which succeed in attracting large number of pupils to use their canteens will face greater challenges in accommodating them all comfortably without creating a crowded environment that would discourage children to attend. Also, although children undeniably have strong food preferences, and use food choices to assert their independence, the act of eating is relatively unimportant when compared with the competing activities of being with friends, socialising during lunchtimes, 'getting away from' the school premises when lessons are not in progress, as well as lunchtime activities such as sports (Wills et al. 2005).

Having to choose between the items on offer at the counter (rather than in advance) has been noted as slowing down the lunch purchasing process (Ofsted 2010a). Displaying menus at the entrance, or outside the dining hall, enables children to make their choices before they reach the food. Menus posted elsewhere in the school would provide the added advantage of promoting the choices available to children who would not usually consider a canteen meal. The author of the present study believes that both

of these techniques should be used whenever possible, due to their low cost and ease of introduction.

School lunchtimes can be as short as 45 minutes, and pupils using the canteen may be attracted to the hatches or counters with the shortest queues. Studies have shown that providing separate queues and tills for different foods, in order to speed the buying process, has proven successful (Bowker et al. 1998). The author of the present study would suggest that schools could work towards ensuring that popular counters have extra staff, so that children are not deterred from using them. Also, schools could operate 'express tills' pre-packaged and quick to serve meals, such as sandwiches, baguettes, wraps and pieces of fruit, to appeal to children's wish to pass through the canteen system as quickly as possible.

School canteens can also encourage the consumption of nutritious meals by promoting and serving more healthy 'eat and go' items, such as low-fat meat or vegetarian burgers in wholemeal rolls, wholemeal sandwiches, baguettes and wraps with low-fat fillings including salad, and cardboard or paper containers of non-fried oven chips. The present study noted that sandwiches, baguettes and rolls were (along with chips and pizza) the most popular canteen choices, and the author believes that schools could promote their 'speedy' advantages to busy pupils who feel they have far more important activities to consider at lunchtime than sitting down and eating in the canteen, by making the areas serving these foods especially efficient and allowing rapid service.

Another means of speeding the lunch purchasing process would be to provide an express till for a limited selection of pre-selected set-price 'meal deals', such as a baguette, a piece of fruit and a bottle of water, or carton of semi-skimmed milk or fruit juice. Children intending to leave school for social reasons could quickly pick up one of these meals beforehand, rather than having to stand in the long queues found at the high street bakers selling much less healthy meal deals, such as a sausage roll, a doughnut and a fizzy drink.

Pre-ordering systems, often linked to the children's prepayment cards, or 'smart cards', where children can pre-order their lunch from a terminal using their card, are used at

many schools (CRB Solutions 2010a). This speeds up the lunch-purchasing process for children. However, no information was available on whether this actually increased the uptake of canteen lunches.

However, it was however noted in the present study, as well as the pilot study conducted by the author (Norris 2005), that, despite their dislike of queues in the canteen setting, children are prepared to wait in long queues for fast food when they choose to eat a street lunch; such is the appeal of the other attractions of this lunch choice, such as the nature of the food available, being with friends, and the sense of asserting one's own independence by leaving school premises.

Cumbersome payment systems

A cashless system, by which children pay for their food using 'swipe cards' or 'smart cards' pre-loaded with money, is now the norm in Scottish schools, and was used in the county of Fife when the present study was conducted. A cashless system speeds the buying process since children do not have to search for money in their bags or pockets, and change does not need to be given. It also allows the anonymous provision of free school meals to children from families with limited incomes. It can also enable pre-ordering of meals (CRB Solutions 2010a).

Some schools using a cashless card system to pay for canteen lunches allow parents to pre-load their children's payment cards, ensuring that the money is spent in the canteen, such as the Impact Cashless Payment System used by Midlothian Council, Scotland (CRB Solutions 2010a). However, if a system involves children topping up their own cards (for example using machines in the dining room), money given by parents to be spent on a canteen lunch may instead be used to purchase a street lunch, or indeed something else entirely. This was the situation in the schools in the present study. Due to concern from parents that money given to their children as 'canteen money' was being used to buy street food, or other items such as cigarettes, moves

were being made towards a system whereby parents of children at these schools could load money onto their children's cards online.

Free school meals for children from low-income families were not considered specifically in the present study. However, smart cards also enable the anonymity of children from low-income families receiving free school meals, which has been found to increase the uptake of free school meals. The introduction of a biometric cashless payment system in a school in County Durham increased uptake of free school meals from 48% to 91% of eligible children in five weeks (CRB Solutions 2010b). Biometric systems, which utilise children's fingerprints for identification, have the added advantage of removing the necessity of cards, which can be lost.

A further advantage of smart cards and biometric systems is that they allow collection of data on children's food purchases. This is a useful technique for nutrition researchers, as evidenced by the wealth of data collected by Lambert's study of primary school children, using 'smart card' technology (Lambert et al. 2005a; Lambert et al. 2005b; Lambert et al. 2005c). Smart or swipe cards also enable the introduction of initiatives whereby healthy purchases are rewarded, providing an incentive both for children to stay in school for canteen lunches, and also to choose the healthier items on the menu when they do so.

Hot meals

The present study noted that hot dishes do not appear to be popular canteen choices, with the only dishes consumed by children in the study being macaroni cheese and chicken curry. Discussion with the catering staff at the two schools in the study indicated that the most popular hot food choices were steak pie, fish, roast beef and macaroni cheese. Because the popularity of hot dishes was so limited, canteen staff only prepared those they expected to be purchased. This gave children little or no opportunity to try new, healthy hot dishes, but the school's motivation in this respect was understandable. In light of children's strong views and motivation for food choices, it appears to the author that the most cost effective route would be to accept that

children do not want traditional hot meals at lunchtime, and work with their preferences in order to offer only the healthy foods that they would eat.

The author would suggest that schools acknowledge children's preferences for foods such as chips and pizzas, and attempt to work within the SNSSL nutritional requirements in order to provide them, for example by providing pizzas topped with only a small amount of low-fat cheese (in order to meet fat, SFA and salt requirements), and oven chips and potato wedges not previously fried in oil (in which case they would be limited to three times weekly under the SNSSL). Potatoes, particularly when served in their skins, are a healthy food, a good source of carbohydrate NSP and vitamin C. Providing low-fat oven chips and wedges would allow these favourite foods to be served daily as an accompaniment, removing the necessity for children to go outside to eat fried chips (as well as other unhealthy foods) if they considered the need for chips essential when deciding where to purchase their lunch.

5.1.6) Increasing the provision of free school meals

It has been noted (Scottish Executive Expert Panel on School Meals 2002, HMIE 2005, Sinclair & Winkler 2008) that price is an important factor in school lunch choice, so making school lunches less expensive, or even free, would almost certainly significantly increase school meal take-up.

In some countries, such as Finland and Sweden, all children up to the age of 16 have free school meals, and the uptake of these is 85% (School Food Trust 2007). In the UK, free school meals are provided for children from families with limited incomes. The Child Poverty Action Group (CPAG) in Scotland has campaigned for free school meals for all (Child Poverty Action Group 2007), and while a proportion of these free meals would be allocated to children whose families could easily afford to pay for them, this would arguably be a worthwhile expense if it improved the nutritional health of the child population, by giving more children a nourishing lunchtime meal. It could be argued that monetary savings would be made further along the line, as today's children would place

fewer demands on Scotland's health service in future, since they would be less likely to grow up to be unhealthy adults.

Thirty-five thousand children took part in a six-month trial of free lunches for children in primary school years 1 to 3 between October 2007 and June 2008, in the Scottish local authorities of Fife, East Ayrshire, Glasgow City, West Dunbartonshire and the Scottish Borders. Uptake of canteen meals increased from 53 to 75%, and some children reported trying new foods and asking for healthier food at home, although it is not known whether their overall diet improved. Following the success of this trial, Scottish legislation was passed in November 2008 to introduce free school meals for children in primary school years 1 – 3 (Scottish Government 2008a) from the school year beginning in 2010. However, concern from opposition politicians was been expressed in the media (BBC News Online 2009) that insufficient funding is available to carry out the plan. In the summer of 2010, in view of the current economic climate, the Scottish Government re-emphasised its commitment to extending entitlement to free school lunches, but clarified that universal provision of free school meals to primary 1 – 3 children would not become universal in 2010, but was a target to be worked towards from that year, beginning with schools in the most deprived areas (Scottish Government 2010a; Scottish Government 2010b).

The cost of such any universal free school meal scheme is likely to prove extremely expensive, notwithstanding the economic situation at the time of preparation of this thesis. This economic reason, as well as the fact that secondary school children have distinctive behaviour patterns that make them less likely to avail themselves of canteen lunches – even free ones – means it is extremely unlikely that any serious proposal would be made for the scheme to be extended to secondary school pupils.

Increasing the number of secondary school children entitled to free school meals under the current benefits-related scheme, or increasing the subsidisation of canteen meals for all (making them more competitive versus street lunch options), might however provide a more economical and cost-effective alternative. However, it must be borne in mind that not all children entitled to free school meals actually eat them – only 69.8% of

those eligible in the case of secondary schools in 2008 (the year of the present study) (Scottish Government 2008).

5.2) Packed lunches

5.2.1) Packed lunches – observations

While the present study found packed lunches to be nutritionally superior to street lunches, they were higher in fat, percentage energy from fat, NMES, and percentage energy from NMES, than canteen lunches. They were also lower in folate and calcium than canteen lunches. Of the three lunch types, packed lunches had the least favourable intake of some nutrients: they had the highest SFA content and percentage energy from SFA, and the lowest NSP content. Positive aspects of packed lunches included the observations that they had the highest mean vitamin A and fruit and vegetable contents of the three lunch types.

5.2.2) Packed lunches – recommendations

Previous research has highlighted the fact that packed lunches are often far from nutritious (Jefferson & Cowbrough 2004; Sodexo 2005). Some schools offer guidance for parents on the contents of packed lunches, for example in the form of suggestions for five days of healthy packed lunches (Bowker et al. 1998), and Fife Council (the region where the present study was conducted) planned to send home packed lunch guidelines with pupils in 2009 (Fife Council 2009). Such advice must be carefully worded. In a report on progress in implementing school food standards (Ofsted 2010d), which mentioned packed lunches, parents indicated that they would prefer guidance on which healthy foods to put in a packed lunch, rather than being told what not to give their children. In addition, they indicated that they believed that providing food their children would definitely eat was more important than abiding by nutritional guidelines. Although many parents may ignore guidelines on packed lunches, or the children may

not give them the guidelines if they are distributed in school, this is an inexpensive intervention that has the potential to reach a significant sector of the school population.

Home economics lessons are a possible means of teaching children about healthy lunchbox food – not just its importance, but also how to prepare it. Concentrating on practical aspects has been found to make the subject of preparing healthy food more relevant to pupils (Hyland et al. 2006), who could go home and show their parents what they had learned. It has already been noted that children have considerable influence over the foods that go into their packed lunches (Brannen & Storey 1998).

The present study has demonstrated that packed lunches are nutritionally superior to street lunches. If more schools prevented children from leaving school premises during lunchtime, and now that children are unable to purchase many of their favourite foods (such as crisps, chocolate-containing foods and fizzy drinks) from the school canteen, more children might choose to bring packed lunches. This was found to occur in both of the schools in the present study (information obtained from telephone conversations with catering staff at St Columba's and Queen Anne High Schools, September 2009).

It is possible that a large proportion of children eating packed lunches were those who would otherwise eat street lunches. If this was the case, their lunch boxes might well be dominated by the snack foods disallowed in canteen lunches, rather than being rich in fruit, vegetables, wholemeal bread and other healthy foods. Due to the preference observed for sandwich fillings such as ham or cheese, the characteristically high SFA intake associated with packed lunches, as noted in the present study, would probably remain.

5.3) Street lunches

5.3.1) Street lunches - observations

Unless lock-in policies can be instrumented, schools will need to accept that a proportion of children will purchase street lunches, and even children eating canteen and packed lunches will often purchase street food on the way to school; this may be eaten immediately, or saved until morning break or lunchtime (Sinclair & Winkler 2008). Because of this, even though the SNSSL standards prevent schools from selling unhealthy foods, these items may be – and often are - brought in to schools and consumed on the premises during school hours.

5.3.2) Street lunches – recommendations

Actions can be taken to limit the nutritional deficiencies and excesses created by the consumption of street food and street lunches. Local councils are often encouraged to work with local traders to encourage them to support healthy eating policy in schools. Examples of how this has been achieved (Scottish Government Education Department 2009a) include moving commercial snack vans so that they are unable to sell from locations close to schools during break and lunch times, and encouraging local traders not to offer 'meal deals' high in fat, salt and sugar, especially if they are targeted at children. Supporting public health promotion in this way can be beneficial to the public image of local businesses, and this incentive could be emphasised to traders. Coverage in the local press could further boost the public image of traders doing their best to improve children's diets.

5.4 'Flitting' between lunch types

It became apparent from the present study that many children did not have the same lunch type every day. When children were categorised as 'habitually' having canteen, packed or street lunches if they ate them on four or five of the study days, it was found that more children (38.6%) did not have a habitual lunch type. (32.8% habitually had a canteen lunch, 15.1% habitually had a packed lunch, and 13.6% habitually had a street lunch).

This indicates that it is common practice for children to 'flit' from one lunch type to another, perhaps according to factors including the items on the canteen menu, what their friends are doing that day, or the weather.

It is encouraging to note that if children were loyal to a particular lunch type, this was more likely to be the canteen lunch than packed or street lunches. If this loyalty can be encouraged, and those who customarily 'flit' between lunch types were also encouraged to have canteen lunches more often, canteen uptake would increase and more children would benefit from the nutritional benefits of this lunch option.

5.5) Mixed lunches

Another phenomenon noted in the present study was that of 'mixed lunches', where children consumed food and drink from more than one lunch type (canteen, packed or street lunch) during a single lunchtime.

Since the present study was concerned mainly with comparing the nutrient intakes of the three separate lunch types, and the proportion of children having mixed lunches was relatively small (8.7% of the lunches consumed), mixed lunches were excluded from the analysis.

However, their importance must not be overlooked, as they account for a significant proportion of the sample, and the effects of mixing lunch types would have an impact on children's nutrition both over the lunchtime and whole day. For example, during lunchtime a child could purchase healthy food in the canteen, but also consume less healthy food brought from home or purchased outside school, diluting the beneficial effect of the canteen lunch. Conversely, if children who would otherwise buy a street lunch for reasons of leaving school to be with their friends, could be encouraged to also consume some healthy food from the canteen (or some healthy packed lunch food) before leaving school, their appetite might be decreased when it came to the point where they would purchase their street lunch.

5.6) The whole school ethos

As well as lunchtime, there are several other eating opportunities during the school day. In the academic year following the data collection for the present study, the canteen at St Columba High School began opening before school, between 8.30am and 9am. Foods served include bacon rolls, scrambled egg rolls, toast, and yogurts conforming to the fat and sugar standards of the SNSSL. Canteen staff informed the author that breakfast opening was proving popular.

5.6.1) Morning breaktime eating

The author of the present study noted that many children consumed relatively large amounts of food (comparable with a lunchtime meal) during their morning break, much of this purchased from the canteen or the vans parked in the playground. Significant break time eating has also been documented elsewhere (Sinclair & Winkler 2008) in a study which found morning break to be the most popular eating occasion between breakfast and going home from school. Although the present study did not separately analyse the nutrient intake of this break time food, it will have contributed towards the children's total nutrient intake, which was analysed. For this reason, although break time food was not analysed specifically, it was considered it worthy of note, since

Sinclair & Winkler's study, in common with the present study, found that some children were eating during morning break instead of having a lunchtime meal. Although the present study did not investigate children's motivations, Sinclair and Winkler's study included a qualitative aspect which revealed that many children ate before lunchtime to keep the lunch break free for other activities such as socialising or football.

The significant amounts of food consumed during morning break were difficult to classify. Because of the time at which they were eaten (between breakfast and the lunchtime meal), the present study categorised them as 'morning snacks', but the amount consumed was more indicative of a meal. Some children ate a lunch-sized portion of food during both morning break and lunchtime. However, in some instances, it could be expected that the amount and macronutrient composition of the food consumed during morning break would affect children's appetites (and therefore their food choices) at lunchtime. (In the present study very few children ate no food at lunch time).

Food consumed during morning break need not be a nutritional problem if it is nutritionally balanced, and excessive quantities are not consumed. However, although the nature of the foods consumed were not analysed in the present study, it was noted that similar food items (for example, baguettes, sandwiches, crisps, biscuits (including chocolate covered) and sugar-sweetened soft drinks) were eaten at morning break time to those consumed at lunchtime. (Pupils from St Columba's High School also consumed food such as deep-fried chips, burgers and sausages from the commercial snack van parked near the school, and foods conforming to the SNSSL regulations (including oven chips) from the council-provided 'Healthy van' on school premises.)

5.6.2) Tuck shops and other school stalls

At St Columba's High School, pupils also had access to a tuck shop during morning break and lunchtime, where they were able to purchase foods not permitted in the canteen by the SNSSL, such as confectionary and sugar-sweetened soft drinks. This tuck shop was closed after the present study was conducted, due to the conflicting

messages it sent out to the healthy eating messages conveyed by the canteen menu and home economics lessons. Another factor contributing to the closure of the tuck shop was that when items forbidden by the SNSSL had to be removed from sale when the new regulations came into force (Scottish Government 2008b), the venture was deemed unlikely to remain profitable, due to the lower price mark-up on 'healthier' items, and their lower popularity with the pupils.

However, because morning break is a time when many pupils consume a considerable proportion of their school-time food (whether this is for reasons of hunger after an insufficient breakfast, or convenience to lessen the necessity of eating at lunchtime) the beneficial potential for tuck shops should not be dismissed out of hand. Because tuck shops can open during morning break, this provides another opportunity to sell food to children at a time when they might not be permitted to leave, or do not have time to walk far from, school premises. The foods purchased could boost children's intake of healthy foods and decrease their appetite for unhealthy foods at lunchtime, when they have access to a wider range of food items high in fat, sugar and salt.

Fruit only tuck shops have been introduced in several primary schools, and proven popular among pupils (Bowker et al. 1998). Although no published evidence of successful fruit-only tuck shops is available, the author of the present study believes they could also have the potential to increase the fruit intake of older children, by making fruit more easily accessible, something that has been shown to increase fruit consumption in children (Kratt 2000; Reinaertsa et al. 2007; Slusser et al. 2007), and adolescents (Neumark-Sztainer et al. 2003). Pupil involvement can also improve the success of school healthy eating initiatives (Lowden & Schlapp 2002), and allowing older pupils to sell the fruit, and consulting all pupils on its choice and presentation) might also increase uptake.

To appeal to children's attraction to new ideas, other novel variations on the tuck shop could be tried, such as juice and smoothie bars, which had already proven successful at

St Columba's High School (personal observation by the author, prior to conduction of this study).

It was noted in the present study that milk was popular among the children, so the author suggests that milk bars selling single-serving cartons of semi-skimmed milk, and/or healthy milkshakes made of milk and fresh fruit (such as bananas and berries), perhaps with the inclusion of low-fat natural yogurt, could be another intervention worth attempting. The nutritional benefits of soup – another popular food in this population, particularly in Scotland (Gregory & Lowe 2000) – have already been addressed in this discussion, and 'soup bars' open at morning break would be another opportunity to boost children's intake of nutritious food.

5.6.3) *Vending machines*

The vending machines situated in the canteen at St Columba's High School, and elsewhere in the school at Queen Anne High School, were popular among the children in the present study, but it was noted that the foods purchased tended to be those which would not be permitted under the new SNSSL standards (Scottish Government 2008b), such as chocolate-covered wafer biscuits and sports drinks. After the completion of the present study, and with the introduction of the new standards, the foods stocked in the vending machines were brought into line with the SNSSL. The pupils' response to this is not known.

Vending machines would seem a useful means of providing healthy food to children, thanks to their attraction to convenience and speed of purchasing. However, vending machines are often required to produce a profit for schools. Although this would generally be easily achievable using popular manufactured foods high in fat, sugar and salt, such as chocolate, crisps, confectionary and fizzy drinks, this might not be possible with more nutritious foods such as fruit, fruit juice, cartons of UHT semi-skimmed milk, and bottled water, which would not have such a high mark-up or popularity. The American 'CHIPS' study found that price reductions of low-fat foods in vending

machines increased uptake among adolescents and adults, so that profitability of the machine was not affected (French et al 2001).

Fresh foods, such as sandwiches, baguettes and wraps, have proven popular at other school outlets, and versions including healthy ingredients (such as salad and lean meat) appeared no less popular with children in the present study. However, most fresh foods require refrigeration, and frequent cleaning would be necessary to remove uneaten foods, so stocking would require precise estimations of likely sales to avoid wastage, and maintenance of the machines would require extra labour. This obstacle has been noted elsewhere (Bowker et al. 1998).

5.7) Considering the big picture

The present study has shown that the food consumed at school makes an important contribution to children's overall diets. Health Promoting Schools can also impact upon children's eating preferences, both now and in the future, as well as enabling children to pass on healthy eating messages and behaviours to their families.

However, despite this great potential for benefit to children's health, the fact remains that the children's whole environment must be considered. The words 'obesogenic environment' have been used to describe the environment so common today whereby various features of a person's environment – physical, social, economic and cultural – make it more easy for him or her to become obese than to remain a healthy weight (Egger & Swinburn 2007). In addition, the modern physical, social, economic and cultural environment not only predispose to obesity, but also to health conditions such as cardiovascular disease and various cancers, related to the non-calorific effects of excessive intakes of SFA, NMES and salt, and deficiencies in micronutrients, (World Health Organization 2003).

Despite the importance of nutritional education provided by school, both from lessons (other parts of the curriculum as well as home economics) and the whole school ethos regarding healthy living (for example the nature of foods served from the canteen and

other sources), most of children's information on food has been found to come from their parents (Seaman et al. 1997). Also, parental consumption of fruit and vegetables is one of the main determinants of a child's consumption (Reinaerts et al. 2007). Therefore the home environment and outside must also be considered, rather than concentrating solely on schools.

5.7.1) Targets for interventions

Parents are vital when considering children's nutritional health; they are the main food providers, as well as educators and role models. In some cases, parents can be a barrier to the improvement of their children's diet. If the parents have been brought up to consider an unhealthy diet 'normal', and lack the knowledge, motivation or confidence to make changes in their family's diet, children may be absorbing healthy eating messages at school, but finding it difficult to eat healthily at other times, when food choices are dictated by their parents. In a study conducted in Australia involving teenagers slightly older than those in the present study, the lack of suitable foods at home, and the inability to influence family food choices, were significant barriers to healthy eating (Gracey et al. 1996). An after-school club for 12 – 13-year-olds in a low-income area in the North East of England increased children's knowledge of healthy eating and produced some evidence of them being more involved in food preparation in the home. However, little change occurred to their diets. It was noted that although the children's parents had a positive attitude to their children's participation in the club, their attitude to the healthy eating messages that their offspring brought home was varied. The study's authors suggested that children's lack of power over family food choices could be the reason for at least some of this intervention's lack of effectiveness regarding changing the children's diets (Hyland et al. 2006).

Parents would seem ideal targets for interventions aimed at improving children's diets, such as seminars and cookery classes. But with today's busy lifestyles, and many parents juggling careers and childcare, it may be difficult for them to find time for activities outside the home.

Classes and courses are excellent ways of passing on practical food skills, since parents can gain practice in techniques and ask questions as they arise. Because of parents' work and family commitments, course providers should work in consultation with parents as to which, if any, times and locations are convenient for them. However, the author of the present study was unable to find any evidence of courses actually changing the food parents chose to cook at home for the better.

Parents who cannot attend courses and receive face-to-face instruction, can learn how to improve their families' diets in other ways, which in general would be cheaper to provide. In view of the lack of evidence for the effectiveness of classes, this kind of less expensive means of providing knowledge and skills, could be advantageous. In addition, printed information can be distributed, but it must be accessible, quick to read and, above all, practical, if it is to be heeded. Leaflets and booklets on preparing quick, inexpensive and nutritious packed lunches could prove useful, as could media articles, for example in local and regional newspapers.

The internet is another valuable public health resource that parents can access from home. Local public health initiatives could provide information for parents such as quick and simple family meal recipes, ideas for involving children in food preparation, and how to plan a healthy diet. Regular e-mail newsletters or updates, podcasts, user forums, and internet chats with community dieticians, could make parents more likely to keep checking the website, and also encourage them to provide feedback to enable the monitoring of the scheme's success. If school or council budgetary and personnel constraints do not permit publishing their own internet resources, the school website could direct parents to the many excellent independent nutritional information sources, such as the public information website provided by the School Food Trust (School Food Trust 2010), and the Food Standards Agency's 'Eat Well' website (Food Standards Agency 2010). Interventions utilising printed and online information also have the advantage of being less expensive than face-to-face classes for parents.

However, in order for parents – and children – to take advantage of any intervention to improve their nutritional and overall health, they must care enough to change their

behaviour. All too often, adults (and children even more so) ignore the link between diet and chronic diseases such as cardiovascular disease, type 2 diabetes and cancer, believing that 'it will never happen to me', or that they would prefer to eat the foods they have always done enjoyed, and worry about the consequences later. This presence of knowledge, but lack of action, has also been noted in the literature (Gracey 1996; Hyland 1996; Brannen & Storey 1998; Lowden & Schlapp 2002).

Before Scotland's – and indeed the western world's – health can be improved, we need a step change in attitude. Diet needs to be made real – and relevant.

5.8 Limitations and strengths of the present study

At the outset of the present study, it was decided that it would not be feasible to sample a totally representative cross section of Scotland's child population, to include a variety of environments (such as rural and urban, island and mainland) socio-economic profiles, and school types. This was due to financial, logistical, manpower and time constraints. Instead it was decided to select schools which were, in the opinion of the author, 'broadly representative' of the population in that they were neither inner-city nor rural, the schools were neither very small or large, with between them a representative socio-economic profile based on the proportion of children eligible for free school meals (one school having an entitlement for free school meals 4.3% higher than the national average, the other a percentage entitlement 5.2% lower than the national average).

It was accepted that a sample of only two schools, from within the same town, was not a representative sample of Scotland's total population. Therefore the sample size was maximized in an attempt to compensate for this, resulting in a large sample size for a study of this type (1,532 days'-worth of meals analysed).

A degree of selection bias operated on the sample in that, of the three schools approached, only two agreed to participate in the study, and it is possible that these two schools could have been those most concerned about promoting healthy eating, which

may have been reflected in their whole-school ethos, and by extension the food environment the pupils encountered there.

Other means by which selection bias operated on the sample were the opt-out system where parents were able to prohibit their children from participating in the study, and the fact that children were able to withdraw from the study at any time without giving a reason. These factors select for participants included in the final analysis being those from families most interested in nutritional matters, and also those children with the most diligent personalities.

Data was collected during the winter (September to December) and spring (January to March) terms, but not the summer term. Hackett's study of 11 – 13-year-old children in England (1985) noted that although seasonal variations in the intake of different foods could be strong, the seasonal effect on nutrient intake (the focus of the present study) appeared to be small and unlikely to complicate many surveys. A review of the literature found significant seasonal differences in nutrient intake to be limited to vitamin C, and these differences varied with the study setting (country) (see section 1.12.6 on reliability). In addition, vitamin C was not one of the nutrients selected for analysis in the present study.

Due to constraints regarding resources and the schools' prohibition of collecting urine, blood or anthropometric data from the children (Section 1.11.12) a validation study was not carried out prior to the present study. However, a pilot study was conducted to test elements of the methodology (Section 2.2.8).

Estimated intake methodology was used rather than weighed intake after a review of the literature suggested that this was the most appropriate methodology for the study population (see Sections 1.12.1 and 1.12.6). The number of sets of scales available, along with the impracticality of weighing street food at the time of consumption, was a further reason for rejecting the use of weighed intake (Section 1.12.6).

The sources of error inherent in virtually all dietary studies, including recording error, under- and over-reporting, the effect of participation in the study on usual behavior, the

error inherent in the use of food tables and databases, and variations between the nutritional composition of branded foods and home-cooked foods, are also acknowledged.

Chapter 6 – Summary, key findings and further research

6.1) Summary

Overall dietary quality

The variability of nutrient intake among children in the study sample (children aged 11 – 14 living in Fife, Scotland) was very large. However, although their mean daily energy intake was very close to the Estimated Average Requirement, the intakes for fat, SFA and NMES were in excess of the Dietary Reference Value (DRV) (Department of Health 2003b) especially in the case of NMES.

Mean intakes of NSP and micronutrients were below the Reference Nutrient Intake (RNI). Mean intakes for folate and calcium were closest to the recommendations. The lowest mean intakes in comparison with the recommendations were for NSP, and fruit and vegetables (where intake was compared with the Government recommendation for a minimum five portions of fruit and vegetables daily (Department of Health 2003a).

For each nutrient considered (plus fruit and vegetables), fewer than half of the days met the DRV or recommendation. The nutrients / foods for which fewest days met the target were iron (16%), NSP (7%) and fruit and vegetables (2%).

Lunchtime choices

A large proportion of the children (38.6%) did not have a habitual lunch choice, but rather ‘flitted’ between canteen, packed and street lunches on different days. In addition, some children consumed lunch from more than one lunch type (for example canteen lunch supplemented by street food) on a single day.

Lunchtime intake

Of the three lunch types (canteen, packed and street), canteen lunches showed the most favourable nutrient profile when compared with recommendations. Canteen lunches had the lowest mean values for fat, SFA and NMES content, and the highest

mean folate, calcium and iron contents. They did not show the least favourable intake for any nutrient.

Packed lunches contained more vitamin A, and fruit/vegetable portions (mean values). They contained more SFA than canteen or street lunches.

Street lunches did not show the most favourable intake (whether that was high or low) for any nutrient (mean values), and showed the least favourable for all but SFA. They contained the most fat and NMES, and the least vitamin A, folate, calcium, and fruit/vegetable portions of the lunch types.

More lunches (from all lunch types, canteen, packed and street) achieved the SNSSL requirements for nutrients and foods for which a maximum was set (fat, SFA and NMES) than met those for which a minimum was set (NSP, vitamin A, folate, calcium, iron, and fruit and vegetables).

For canteen lunches, the mean intakes of energy, fat, SFA and NMES met the SNSSL standards, but street lunches exceeded the maximums set by the SNSSL for fat, SFA and NMES. Energy intake from packed lunches fell below the SNSSL, but their mean intake for fat, SFA and NMES exceeded the standards.

Regarding NSP, vitamin A, folate, calcium, iron, and fruit and vegetables, only packed lunches met any of the SNSSL standards (that for vitamin A). The most extreme deficiencies in mean nutrient / food intake (for all lunch types) were seen for iron, and even more so for fruit and vegetables. The nutrient for which fewest children met the SNSSL requirement was iron (fewer than 1% for all lunch types).

Contribution of lunches to total daily nutrient intake

Canteen lunches made a greater percentage contribution than packed or street lunches, to the daily intake of NSP, folate, calcium and iron (and NSP and iron were the nutrients which showed the most severe deficit in terms of total daily intake). Packed lunches made the greatest contribution to daily vitamin A, and fruit and vegetable intake (which showed an even greater shortfall in the present study when compared to dietary

targets than NSP and iron) and also to SFA intake. Street lunches made the greatest percentage contribution to fat and NMES intake.

Lunchtime nutrient density

Canteen lunches showed the most nutritionally favourable density (of the three lunch types) for fat, NMES, NSP, folate, calcium and iron. They did not show the least favourable nutrient density for any nutrient, or fruit and vegetables.

Packed lunches showed the highest nutrient density for vitamin A, but also the highest density for fat and SFA.

Street lunches did not show the most nutritionally favourable density for any nutrient, or fruit and vegetables. They showed the least favourable nutrient density for NMES, NSP, vitamin A, folate, calcium, iron, and fruit and vegetables (this encompassed all of the nutrients and foods considered, with the exception of SFA).

Total daily intake

When total daily intake was analysed, canteen lunch days showed the most favourable overall nutrient profile, and street lunch days the least favourable.

On canteen lunch days, children consumed the least fat, SFA and NMES, and the most folate and calcium. Canteen lunch days did not show the least nutritionally favourable total daily intake for any nutrient, or fruit/vegetables.

On packed lunch days, children consumed the most NSP, vitamin A, iron, and fruit and vegetables (though the difference between these values and those for canteen lunches were small, and often failed to reach statistical significance). Packed lunch days did not show the least favourable total daily intake for any nutrient, or fruit/vegetables.

Once again, the street lunch category fared most poorly, with the least favourable (highest) intake for fat, SFA and NMES, and also the least favourable (lowest) intake of NSP, vitamin A, folate, calcium, iron, and fruit/vegetables.

Although the mean intakes on canteen lunch days met the maximum value set as the DRV for fat, SFA and NMES, this was perhaps due to their proportionally lower food

and energy intakes. However, canteen lunch days failed to meet the minimum value set as the DRV for NSP, vitamin A, folate, iron, and the Government recommendation for fruit and vegetable portions.

The mean intakes on packed lunch days met the DRV for fat, SFA and NMES (ie the intakes were acceptably low). However, packed lunch days failed to reach the DRV for NSP, vitamin A, folate, calcium and iron.

The most extreme failures to meet the DRVs and fruit and vegetable recommendation were seen on street lunch days. Mean intakes for street lunch days exceeded the EAR for energy, and the DRV for fat, SFA and NMES. Street lunch days also failed to achieve the DRV for NSP, vitamin A, folate, calcium and iron, and the Government recommendation for fruit and vegetables.

For none of the micronutrients, NSP or fruit and vegetables, did days including any of the lunch types (mean intake) provide 100% of the DRV or recommendation. The most severe deficits were seen for NSP, iron, and fruit and vegetables. For vitamin A, and fruit and vegetables, packed lunch days provided intakes closest to the recommendation. (It was also noted that intakes of NSP and iron were marginally closer to the DRV on packed lunch days than canteen lunch days, and the DRV for calcium and folate was marginally closer to the DRV on canteen lunch days than packed lunch days. However, in these cases the difference in intake between canteen and packed lunch days failed to reach statistical significance.

Total daily intake of fruit and vegetables showed the greatest deficit in comparison with the dietary target – this was the case for canteen, packed and street lunches. The mean intake on packed lunch days (which provided the largest intake out of the three lunch types) provided only 28% of the target.

Whole day nutrient density

When nutrient density (per 100kcal) was calculated, canteen lunch days produced the highest density (of the three lunch types) for NSP, folate, calcium, iron, and fruit and vegetables, and did not produce the lowest density for any of these. Packed lunch days showed the highest density for vitamin A, and also for SFA. (This was very similar to the situation for nutrient density for canteen and packed lunches).

Street lunch days did not show the most nutritionally favourable density for any nutrient, and showed the least favourable nutrient density for all nutrients (plus fruit and vegetables) except SFA. They did not meet the nutrient density provided by a hypothetical day meeting the DRV for any nutrient, or fruit and vegetables.

The nutrient densities of canteen lunch days generally reached that of a hypothetical day where the DRV was achieved. However, due to the relatively low energy intakes on canteen lunch days, in the study they often did not achieve the DRV when intake was considered.

The NSP densities for canteen, packed and street lunches, and also for days including them, were very similar, with differences failing to meet statistical significance in many cases.

The superiority of canteen lunches

Canteen lunches provided a superior nutritional profile to packed or street lunches, in terms of nutrient intake, and especially in terms of nutrient density. Also, the advantages in terms of nutrient intake provided by consuming a canteen lunch were still apparent when the whole day's nutrient intake and density were considered.

In addition, on days when a canteen lunch was eaten, the food consumed at other times of day was generally less conducive to good health (higher in fat, SFA and NMES, and lower in NSP, vitamin A, folate, calcium, iron and fruit/vegetables) when compared with the food eaten at lunchtime.

It was also noted that, despite their nutritional superiority in other respects, canteen lunch days provided too high a proportion of the DRV for SFA and NMES, and not a high enough proportion of the DRV or recommendation for NSP, vitamin A, folate, calcium, iron, and fruit and vegetables.

The main shortfalls in canteen lunches were calcium, iron, NSP and, most notably, fruit and vegetables.

The street lunch was the least lunchtime option least conducive to good health, and the nutrition it provided was so poor that this was not compensated for over the rest of the day.

However, regardless of whether a canteen, packed or street lunch was consumed, when total daily intake was analysed, no significant difference was found in the intakes of NSP, calcium and iron.

6.2) Key findings

- Overall, the diets of schoolchildren in this area of Fife, Scotland, were nutritionally poor.
- The whole sample had particularly poor intakes of NSP, iron, and fruit and vegetables, both at lunchtime and over the whole day.
- When canteen lunches were consumed, the diet was more conducive to the guidelines for good health, both at lunchtime and over the whole day.
- When street lunches were consumed, children had the lowest intake and nutritional density for NSP, micronutrients, and fruit and vegetables. This was the case both at lunchtime and over the whole day.
- In the case of street lunches, there was some compensation for poor lunchtime nutrient intake by foods eaten at other times during the day. However, this was not as great as that noted by previous studies, and many significant differences between the lunch types existed at the end of the day.
- Children should be encouraged to have canteen lunches. Government and individual councils and schools should consider a lock-in policy to prevent children from consuming street lunches.

6.3) Further research

Suggestions for further research:

6.3.1) Further analysis of data collected, which is beyond the aims and objectives of this PhD:

- Analyse data separately for males and females.
- Extract data on zinc intakes from WinDiets analysis, and compare with the requirements of the new Scottish Nutrient Standards for School Lunches, which were not in force at the time of the present study. Zinc was not included in the version of the SNSSL in place at the time of the present study (Scottish Executive 2003b), but is included in the new SNSSL (Scottish Government 2008b).
- Compare mixed lunches with 'pure' canteen, packed and street lunches. Use data from SPSS to analyse mixed lunches (containing elements of more than one of the lunch types: canteen, packed and street). Determine the nutritional contribution made by canteen, packed and street lunch food on mixed lunch days, to the overall lunchtime food intake.
- Conduct a 'child-centred analysis' using 'database 1' (compiled as part of the present study, see Methodology). The analysis for this thesis utilised database 2, which enabled analysis of each individual lunch consumed, but did not allow investigation of the **habitual** lunch types taken by particular children.
- Refer back to the food diaries completed during the present study, to conduct an analysis of foods and/or food groups consumed.
- Analyse the nutritional contribution of breakfast, and snacks, compared with lunchtime intake, and as a contribution to total daily intake, in the present study.
- Investigate the foods and food groups consumed during breakfast and as snacks.

6.3.2) *Future research*

- Investigation of children's motivation for choosing lunchtime food, in order to increase take-up of canteen meals and improve lunchtime and overall nutrition.
- Research into whether nutrient intakes provide a valid measure of potential to impact health, using biomarkers such as blood or plasma levels of nutrients.
- Research into tracking of behaviour – how do lunchtime eating choices change when children move from primary to secondary schools, particularly in the light of the earlier introduction of the more stringent nutritional standards (Scottish Government 2008b) in primary schools.
- Since many children in the present study consumed sizeable 'meals' during their morning break (as well as or instead of a meal during the lunch break), research into the relative importance of these eating occasions would be valuable.
- More interventions to increase the uptake of canteen lunches, and especially the intake of fruit and vegetables, should be initiated. These should be monitored, analysed, and their results compared and shared.

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APPENDICES



Queen Margaret University
EDINBURGH

Mr Colin Grant
St Columba's RC High School
Woodmill Rd
Dunfermline
KY11 4UN

Dear Mr Grant

I am a mature student living in Dunfermline working on a PhD at Queen Margaret University, Edinburgh. This PhD is fully funded by Queen Margaret University, with no involvement from any other funding sources.

I am interested in discovering which is the 'most nutritious' kind of school day lunch: school lunch, pre-paid school lunch, packed lunch, and lunches eaten by those who visit local fast food establishments and food shops ('street lunches').

What I would like to do, some time during September/October 2007, is to ask S2 pupils at your school what they eat for lunch. This will involve filling in an anonymous food diary, which I will provide, covering one school week. After the survey week, I would collect the diaries.

After the diaries have been analysed, I would provide you with the data on the nutrient contents of the different lunch types. I am sure this will be very interesting for yourself, staff, parents and pupils.

I do hope you will feel able to agree to my request. If you have any questions, or areas you would like to discuss further, myself and my supervisor would be pleased to talk this through with you.

I look forward to receiving your reply.
Yours sincerely

Carina Norris BSc MSc RNutr
CNorris@qmu.ac.uk

Michael Clapham BSc MSc RNutr RD
Lecturer, PhD Supervisor, Queen Margaret University. MClapham@qmu.ac.uk. 0131 317 3651



Queen Margaret University
EDINBURGH

Information Sheet

Dear parent or guardian

My name is Carina Norris and I am a postgraduate research nutritionist in the School of Health Sciences at Queen Margaret University in Edinburgh. I am undertaking a research project for my PhD. The title of the project is: "Comparison of the nutrient content of different types of lunchtime meal, and their contribution towards the overall daily nutrient intakes of 12-13-year-old schoolchildren from two schools in Scotland."

Queen Anne High School has given approval for the project.

This study is looking into the nutritional content of children's diets. We expect your child to find it fun to complete, and any child in year S2 is eligible to take part.

If you are happy for your child to take part, he or she will be asked to complete a simple 'food diary' of the foods eaten over the five days of a school week. There will also be space inside the diary for your child to fill in a few questions including gender and whether they have free school meals.

All data will be **completely anonymous** - children will be identified only by a number, and their **names will not be recorded at any stage**. Food diaries will be handed out during home economics lessons, but the study is not compulsory.

If you would like to contact an independent person, who knows about this project but is not involved in it, you are welcome to contact Dr Jane MacKenzie (details below).

Results from the study may be published in a journal or presented at a conference.

If after reading this information sheet, and having any other questions answered, you would **not** like your child to be a participant in the study, please sign the separate opt-out form and return it to the school. If you are happy for your child to take part, you need take no further action

Thank you

Carina Norris

Researcher: Carina Norris, Research Nutritionist, School of Health Sciences, Queen Margaret University, Clerwood Terrace, Edinburgh EH12 8TS. Email: CNorris@qmu.ac.uk

Independent adviser: Dr Jane MacKenzie, School of Health Sciences, Queen Margaret University, Clerwood Terrace, Edinburgh EH12 8TS. Tel: 0131 317 3651. Email: jmackenzie@qmu.ac.uk



Queen Margaret University
EDINBURGH

Information Sheet

Dear student

My name is Carina Norris and I am a Research Nutritionist in the School of Health Sciences at Queen Margaret University in Edinburgh. I am doing a research project for my PhD. This project is about the nutritional content of school pupils' diets and I am looking for volunteers to take part in the project. It should be fun to complete, and any pupil in S2 can take part.

The title of the project is: "Comparison of the nutrient content of different types of lunchtime meal, and their contribution towards the overall daily nutrient intakes of 12-13-year-old schoolchildren from two schools in Scotland."

Queen Anne High School has given approval for the project.

If you take part, you will be asked to complete a simple 'food diary' of the foods eaten over the five days of a school week. There will also be space inside the diary to fill in a few questions on things like whether you are a boy or girl and whether you have free school meals.

All data will be **completely anonymous** - pupils will be identified only by a number, and their **names will not be recorded at any stage**.

If you would like to contact an independent person, who knows about this project but is not involved in it, you are welcome to contact Dr Jane MacKenzie. Her contact details are given below.

Results from the study may be published in a journal or presented at a conference.

If you have read and understood this information sheet, any questions you had have been answered, and agree to taking part, please now see the consent form, and sign and return it to your school.

Thank you

Carina Norris

Researcher: Carina Norris, Research Nutritionist, School of Health Sciences, Queen Margaret University, Clerwood Terrace, Edinburgh EH12 8TS. Email: CNorris@gmu.ac.uk

Independent adviser: Dr Jane MacKenzie, School of Health Sciences, Queen Margaret University, Clerwood Terrace, Edinburgh EH12 8TS. Tel: 0131 317 3651. Email: jmackenzie@gmu.ac.uk



Queen Margaret University
EDINBURGH

HOW TO FILL IN YOUR 5-DAY FOOD & DRINK DIARY

GOLDEN RULES

All you need to do is:

Write down

- **What** you eat (or drank)
- **How much** you ate
- **When** you ate it
- **Where** it came from

Please eat just as you would normally – don't change your diet in any way. We want to know what you really eat, not what you or anyone else thinks you should eat!

There are no right or wrong answers, and no need to be embarrassed – your name is not on the diary, so no one will know who you are.

Write down as much detail as possible. But don't worry if you can't get all of the information for all of the food and drink. Just give as many details as you possibly can. Don't leave a food out just because you don't know all of its details.

It's really helpful if you can save wrappers and labels from the foods you eat – things like chocolate bars, crisp packets, cardboard sleeves from ready meals). You'll be given a large envelope to put these into, along with your Food Diary, to hand in at the end of the study.

Please leave a line's space between each meal (or snack) in your Food & Drink Diary.

Helpful hints:

Do's

- DO Write the day and date at the beginning of every page
- DO answer all the questions at the beginning of the Food & Drink Diary (about you). Remember that we're not recording your name, so when all the diaries are collected in, no one will know which belongs to which participant
- DO fill in your diary every time you eat or drink anything, and record the time when you ate the food or drank the drink
- DO take your booklet with you to school, and any other time you will be eating or drinking away from home
- DO record the portion size in as much detail as possible
- DO write where the food is from – home, bought from the school dining room, from a vending machine, bought by you outside school (and if so, which shop)

Don'ts

- DON'T write from memory at the end of the day – it's easy to forget things
- DON'T forget to record snacks, sweets and drinks
- DON'T include leftovers or any food that's thrown or given away – only record the food you actually eat. For example, if you share a packet of crisps with your friend, write down half a packet of crisps

We want you to write down

- WHAT the food was
- WHEN you ate the food (or drink)
- WHERE it came from

WHERE IT CAME FROM:

It's very important that we know where the food is from, eg:

- Home (it was prepared for you at home, or you got it from the cupboards, fridge or freezer)
- Did you bring it from home, and eat it somewhere else (eg on the way to school, at break time)
- Did you buy it yourself (on the way to or from school, or outside school at lunchtime). If you did this, write down where you bought it (eg Asda, McDonalds, Chinese takeaway, snack van)
- Did you buy it from the school dining room?
- Was it from a vending machine at school?
- Was it given to you by a friend (eg sharing a packet of sweets)

WHAT YOU ATE AND HOW MUCH

There are many ways of describing how much food or drink you had. Give as much detail as possible - the more the better.

Here are just a few examples:

- Bowl of cereal - small, medium or large bowl
- Soup - paper or plastic cup, mug, small, medium or large bowl
- Glass of juice - small tumbler glass, tall glass, small, regular, large or extra large cup if bought when you're eating out – also say where you bought it
- Sugar in drinks - how many teaspoons?
- Bread - how many slices? Thick, thin or medium?
- Butter or spread - was it spread thinly or thickly?
- Tea or coffee - a cup or a mug?
- Things that come in packets (sweets, crisps etc) - how many grams was the packet? Did you eat the whole packet?
- Things out of tins – how big was the tin (size in grams) and how much of a tin did you eat?
- Pots, such as yogurts, trifles and other desserts - – how big was the pot (size in grams or ml)?
- Ice cream – how many scoops?
- Vegetables – how many serving spoons full
- Fruit – how many did you eat, and how big were they? (An apple the size of a tennis ball?)
- Pizza – how big was the pizza's diameter (measure across the middle) and how much of it did you eat?
- Rice, pasta etc - how many serving spoons full?
- Other hot foods – how many serving spoons full?

SPECIAL NOTES FOR DIFFERENT KINDS OF FOODS

Brand names

Write down the brand names of makers of foods wherever possible

Eg:

- Asda cheese and onion crisps
- Birds Eye frozen fish fingers
- Batchelors Super Noodles (chicken)
- HP sauce
- McVities HobNobs
- Cornetto mint
- McCains hash browns

Eating out

- Whenever you eat out at somewhere like McDonalds or KFC, write the name of the place and the name of the food (eg McDonalds Crunchie McFlurry)
- Make sure you write the size of the portion (eg large cola, regular fries, small strawberry milkshake)

How was the food cooked? Give details of the cooking methods, eg:

- Chips: oven chips or deep fried?
- Potatoes: baked in their jackets, boiled or mashed?
- Salads: was any dressing added? If so, what kind and how much?
- Meat, fish and chicken: was it plain, battered or covered in crumbs or sauce?
- Meat, fish and chicken: was it baked, roasted, fried, grilled, poached or steamed?
- Eggs: were they boiled, fried, scrambled or made into an omelette?
- Vegetables and fruit: were they cooked or raw?

Manufactured foods:

These include ready meals, meat and fish products, puddings, sweets, crisps etc.

Please give as much information as possible, eg:

- What 'kind of food', eg chilled ready meal, frozen ready meal, tin, packet, tub, bar, etc.
- Brand name, eg Asda, Marks & Spencer, McCains, Stephens the Baker's, Cadbury's, Heinz
- Serving size (how many grams did it say on the packaging, and how much of it did you actually eat? Eg Doritos ready salted 35g bag, Capri-Sun apple juice drink 200ml pouch, Snickers snacksize 42g bar.

Kinds of meat, fish and poultry

- What kind and cut of meat was it, and how much did you eat – eg 1 pork chop, 2 chicken drumsticks
- Was it covered in batter or breadcrumbs?
- Bacon – back bacon or streaky? How many rashers? Grilled or fried?

Fruit and vegetables

- Were they raw or cooked?
- Were they fresh, frozen, tinned or dried?
- Were they peeled, or was the skin left on?
- How big were they, or how big a portion did you have? (eg baked potato with skin the size of a computer mouse, 2 boiled potatoes the size of eggs, a Satsuma the size of your fist, 2 serving spoons of boiled broccoli)

Pasta and rice

- Was it brown or white?
- How many serving spoonfuls did you have? Or how big was the plate or bowl (small, medium or large?)

Soups and stews

- How many ladles-full did you have?
- Or how big was the bowl (small, medium or large?)

Bread etc

- There are many different kinds of bread – we'd like to know which you ate, eg white, brown, wholemeal, stoneground?
- If it was sliced, how thick was it?
- If bread rolls, how big? (eg the size of a computer mouse)
- Was it toasted or 'raw'?
- Was it spread with butter, margarine/spread (if so, what brand, and how much)?
- If you have breadsticks, crackers or crispbreads, write down how many

Spreads and sauces

- Write down if you had butter or spread on bread or toast. If possible, note whether it was low-fat or not, whether it was butter, olive spread, low-fat spread etc
- Write down any sauces you ate, eg: tomato ketchup, brown sauce, cheese sauce, white sauce, salad cream, mayonnaise, salad dressing, mustard, gravy.
- Write down whether salad cream and mayonnaise is low-fat
- Don't forget sweet sauces, eg on ice creams
- Write down the portion size – how many teaspoons, tablespoons, single-serve sachets etc

Milk

- Was it skimmed, semi-skimmed or full-fat?
- If it wasn't cow's milk, say if it was goat's milk, soya milk, oat milk etc
- Don't forget milk added to tea and coffee, eg a dash of milk in your cup of tea.

Cheese

- What kind of cheese was it? (Eg Cheddar, Half-fat Cheddar, Edam, Brie)
- Was it cheesestrings, cheese slices or individual portions or triangles? If so, what brand?
- How big was it (eg the size of a matchbox or twice the size of a matchbox?)
- What 'strength' was the cheese (eg mature, strong, medium, mild)

Yogurts and fromage frais

- What was the brand name, flavour and serving size?
- Was it 'diet', low-fat, thick and creamy, Greek style?

Breakfast cereals (these include Cornflakes and other 'box' cereals, porridge, muesli etc)

- Write down the name of the cereal (eg Kelloggs Crunchy Nut, Tesco porridge oats)
- The number of bowlfuls or sachet you had, and how big they were (small, medium, large)
- Don't forget to write down the type of milk you used (skimmed, whole milk etc)

Jams, honey, marmalade, marmite, chocolate spread etc

- Write down the amount in teaspoons, or individual portion-packs

Sweets, chocolate, crisps and other savoury snacks, biscuits, cakes

If it came from a packet, write down:

- The brand name and product name (eg Freddo, Maltesers Planets, Rowntrees Fruit Pastilles, Maynards Wine Gums)
- The portion size (eg 1/6 of an Asda chocolate sponge cake, ½ bag of Haribo Starmix, a 30g pack of Walkers ready salted crisps, an individual McVities Galaxy Caramel Cake Bar)

If you bought it 'loose' from a bakery etc, write down:

- The place you bought it, (eg Tesco bakery, Greggs, Stephens the Bakers)
- What it was, and how big it was

Sugar

- If you add sugar to anything (eg drinks, cereal) write down the number of teaspoons

Drinks

These include things like water, pure fruit juice, squash, juice drinks, soft drinks like cola and Irn Bru, energy drinks, tea, coffee. Write down as much information as possible:

- Brand name (eg Irn Bru, Robinson's Orange Barley Water, Ribena Extra Light)
- Size of portion (eg cup, small glass, large glass, can, 330ml bottle, 2 litre bottle (or however much of a 2 litre bottle you drank)).
- If you bought it when you were eating out, write where you bought it (eg McDonalds) and the serving size (eg regular, large)
- Was it regular or diet/sugar free?

Home made dishes

Please write down as much detail as possible, (Eg: home made vegetable soup (large bowl), home made shepherd's pie (1/2 medium plate), home made currant scone, home made flapjack)

If you can get the recipe from whoever made it, please write it in the back of this book (use extra sheets of paper, and put them in your envelope, if you run out of space. If you can't get the recipes, don't worry, just write down as much information as possible.

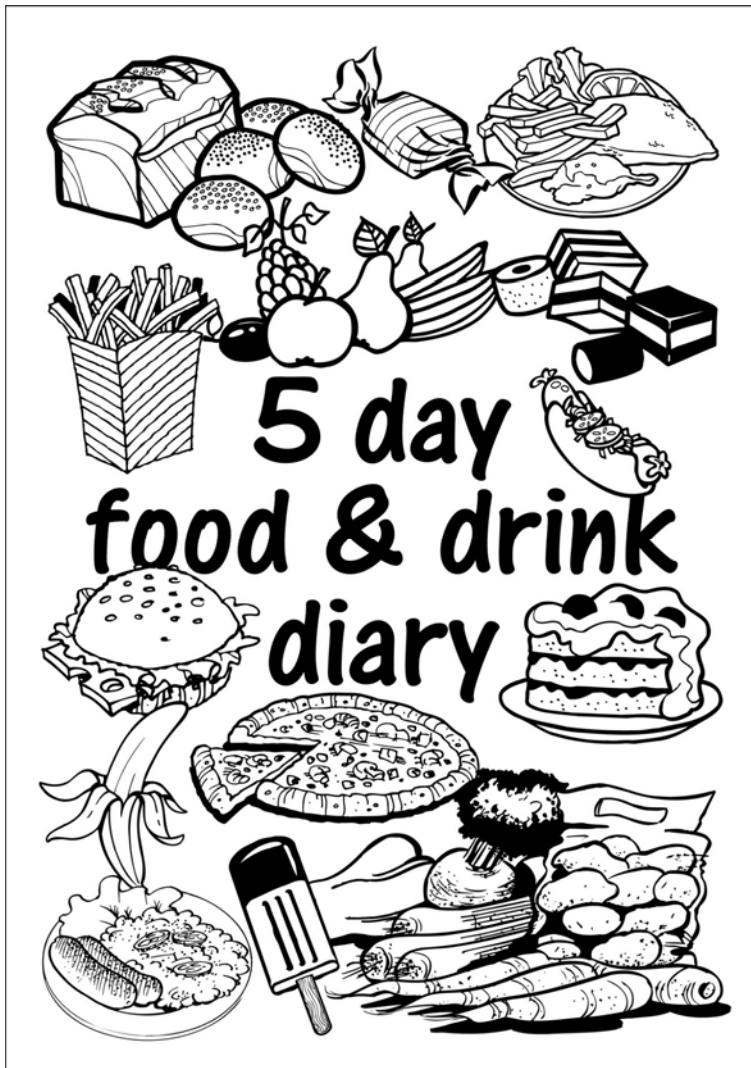
Vitamins and other nutritional supplements

- There's a space to write these down at the beginning of each day's record. Please write down the brand name and what they're called (eg Sanatogen Kids A-Z, Eye Q Chews, Haliborange Advanced Formula Omega-3 Fish Oil For Kids Boots Chewable Multivitamins 3 years - 12 years)

Thank you for all your help, and for filling in the food diary.

Food diary

Food diary cover



<p>QUESTIONS ABOUT YOU</p> <p>You don't need to write your name, so no one will know these are your answers and Food Diary.</p> <p>Are you a boy or a girl?</p> <p>How old are you?</p> <p>Are you a vegetarian?</p> <p>Are you on a special diet for medical reasons (eg coeliac disease)</p> <p>Are you eligible for free school meals?</p> <p>Which kind of lunch do you usually have on a weekday during term time?</p> <p>School lunch</p> <p>Free school lunch</p> <p>Packed lunch</p> <p>Lunch bought yourself out of school</p>	<p>Golden Rules:</p> <p>Do's</p> <ul style="list-style-type: none">● DO Write the day and date at the beginning of every page● DO Leave a blank line between each meal and snack● DO take your booklet with you to school, and any other time you will be eating or drinking away from home● DO write down as much detail as possible● DO make sure you write where the food is from - from home, bought from the school dining room, from a vending machine, bought by you outside school (and if so, which shop)● DO save wrappers and packets when possible and put them in the envelope you'll be given <p>Don'ts</p> <ul style="list-style-type: none">● DON'T write from memory at the end of the day - it's easy to forget things if you leave them until later.● DON'T forget to record snacks, sweets and drinks● DON'T include leftovers or any food that's thrown or given away- only record the food you actually eat. For example, if you share a packet of crisps with your friend, write down half a packet of crisps
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EXAMPLE

Day 1 Day of week: *Monday*

Date: *10 September*

Vitamins/supplements: *Sanatogen Kids A-Z*

Time of day	Details/description of food/drink	Amount eaten/drunk	Where it came from (home, canteen, bought it yourself outside school etc)	Other notes
<i>7am</i>	<i>Frosties</i>	<i>Medium bowl</i>	<i>Home</i>	
	<i>Semi-skimmed milk</i>	<i>Medium bowl</i>	<i>Home</i>	<i>Milk covered</i>
				<i>cereal</i>
	<i>Toast (white bread)</i>	<i>1 thick slice</i>	<i>Home</i>	
	<i>Low-fat spread (Tesco)</i>	<i>Thinly spread</i>	<i>Home</i>	
	<i>Gales Runny Honey</i>	<i>1 teaspoon</i>	<i>Home</i>	
	<i>Semi-skimmed milk</i>	<i>1 medium glass</i>	<i>Home</i>	
<i>10.30</i>	<i>2-finger Kit-kat</i>	<i>1 Kit-kat</i>	<i>Home</i>	
<i>12.30</i>	<i>Chicken McNuggets</i>	<i>6 pieces</i>	<i>McDonalds</i>	<i>Bought myself</i>
	<i>BBQ Dip</i>	<i>1 pot</i>	<i>McDonalds</i>	<i>Bought myself</i>
	<i>Fries</i>	<i>Small portion</i>	<i>McDonalds</i>	<i>Bought myself</i>
	<i>Gingerbread man</i>	<i>1 biscuit</i>	<i>Somerfield</i>	<i>Bought myself</i>
	<i>Rowntrees fruit gums</i>	<i>1/2 packet</i>	<i>Somerfield</i>	<i>Bought myself</i>
	<i>Can of Irn Bru</i>	<i>330ml can</i>	<i>Somerfield</i>	<i>Bought myself</i>

EXAMPLE CONTINUED

Day 1 continued Day of week: Monday

Date: 10 September

Time of day	Details/description of food/drink	Amount eaten/drunk	Where it came from (home, canteen, bought it yourself outside school etc)	Other notes
3.45pm	Curlywurly	1 bar 26g	Corner shop	Bought myself
4pm	Apple Tango	1 330ml can	Home	
	Hula Hoops (original)	1 35g packet	Home	
6pm	Birds Eye Simply Cod in crumbs	1 piece	Home	Baked not fried
	Peas	2 serving spoons	Home	Frozen peas boiled
	Sweetcorn	2 serving spoons	Home	Tinned heated
	New potatoes	4, walnut-size	Home	Peeled and boiled
	Apple crumble	Small bowl	Home	Home made
	Ambrosia low-fat custard	Small amount	Home	Large carton shared between 4
	Water	Medium glass	Home	
9pm	Penguin biscuit	1 bar	Home	
Also had	Water	750ml bottle	Home	Had at school

Day 1 _____ Day of week: _____ Date: _____

Vitamins/supplements: _____

Remember to leave a blank line between each meal or snack

[illegible]

<p>NOTES:</p> <p>These pages are for you to fill in any notes, such as the recipes for any home made dishes. If you can't get the recipes, don't worry, just write down as much information as possible.</p> <p>If you run out of space, you can use extra sheets of paper and put them in your envelope along with this Diary and any wrappers and packets you've collected.</p>	<p>NOTES:</p>
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Example of normality tests conducted

The example used is total daily fruit / vegetable intake (number of portions).

Descriptive statistics

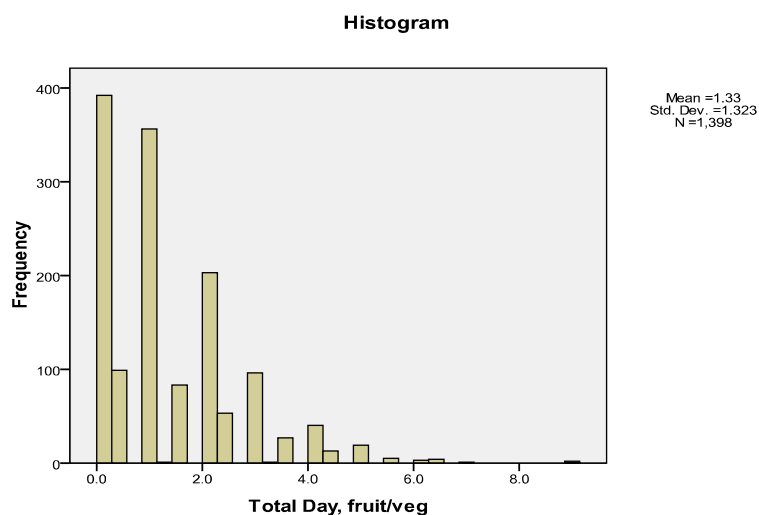
Mean	1.334
Median	1.000
Standard deviation	1.323
Minimum	0
Maximum	9
Skewness	1.322

A normal distribution has a skewness of zero, therefore positive skewness, as above, indicates a distribution tending towards the low end of the distribution.

Kolmogorov-Smirnov test

Kolmogorov-Smirnov		
Statistic	Degrees of freedom	Sig.
0.206	1398	0.000

Sig < 0.05, indicating violation of normality. This was also the case when the sample was split according to lunch type (canteen, packed or street).



Abstract to accompany a poster presentation at the Nutrition Society Summer Meeting, 28 June – 1 July 2010. Nutrition and health: cell to community

Published in Conference and abstract booklet. OC034 p65.

Comparison of the nutrient content of different types of lunchtime meal, and their contribution towards the overall daily nutrient intakes of 11 - 14-year-old schoolchildren from two schools in Scotland.

By C L Norris, HIM Davidson, R Rush and M Clapham, *Health Sciences, Queen Margaret University, Musselburgh, Edinburgh EH21 6UU*

Due to concern regarding the nutritional quality of schoolchildren's diets, large amounts of funding have been invested into improving school canteen lunches. However, children may also consume packed lunches, or 'street' lunches (those purchased outside school). This study was undertaken to ascertain whether canteen lunches are nutritionally superior to packed and street lunches, the contribution of the lunch types towards total nutritional intake, and whether children eating nutritionally poor lunches compensate in terms of nutritional intake and density with food consumed at other times.

During 2007 and 2008, dietary intake data was collected from 332 children aged 11 - 13, from two schools in Fife, Scotland. Using 5-day estimated intake food diaries, data from 1,532 days was collected. Energy intake was calculated, as well as intake and density (per 100kcal) of fat, saturated fatty acids (SFA), non-milk extrinsic sugars (NMES), non-starch polysaccharides (NSP), vitamin A, folate, calcium, iron plus fruit/vegetables. These nutrients/foods were selected due to their inclusion in the Scottish Nutrient Standards for School Meals (SNSSL) ⁽¹⁾. Lunchtime data was compared with the SNSSL, and total daily intake with the Estimated Average Requirement for energy ⁽²⁾, Dietary Reference Values (DRV) and Reference Nutrient

Intakes (RNI) for nutrients and micronutrients ⁽²⁾, and the government recommendation for fruit and vegetables ⁽³⁾. Comparisons were undertaken between canteen, packed and street lunches, and between days including them.

Overall dietary quality was poor. Diet was closest to guidelines when canteen lunches were consumed, having the lowest mean fat, SFA and NMES intakes, and the highest mean folate, calcium and iron. However, many dietary targets remained unmet. On street lunch days, the diet was furthest from guidelines, with the lowest intake for NSP, micronutrients, and fruit and vegetables. This occurred both at lunchtime and over the whole day. Packed lunches contained the most vitamin A, NSP and fruit/vegetable portions (mean values). They also contained more SFA than canteen or street lunches.

There was some compensation for poor lunchtime nutrient intake by foods eaten at other times during the day. However, this was not as great as noted by previous studies ⁽⁴⁻⁶⁾, and many significant differences between the lunch types existed at the end of the day.

Children should therefore be encouraged to have canteen lunches due to their superior nutritional quality, and their contribution towards overall nutrient intake.

References:

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